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THE
GEOGRAPHICAL REVIEW

VOL. XXIII JULY, 1933 NO. 3

PIONEER REACTIONS TO A POOR TROPICAL ENVIRONMENT

A JOURNEY THROUGH CENTRAL AND NORTH AUSTRALIA IN 1932

A. Grenfell Price

THE Federal Territory of North and Central Australia comprises an area of half a million square miles, four-fifths of which lies in the tropical zone. For more than a century the British government, the colony of South Australia, and the Australian Commonwealth have attempted to develop this great region, expending more than £17,000,000 in the effort. Yet today the entire population consists of some 3000 whites, 800 yellow persons, 900 half-castes, and 19,500 aboriginals,[1] while the mining and cattle industries, once promising, have greatly declined.

The "vast undeveloped potentialities" of the Territory are still advertised by some Australian writers, and its northern and wetter region is authoritatively described as an "area of pioneer experimentation, actual or potential." Dr. Isaiah Bowman, questions, however, whether it would not be better to pension off every white man, woman, and child and "give up this painful experiment on an incorrigible frontier, and let the land revert to wilderness."[2] In 1928–1929 Australia made a working loss of £576,024 on the Territory and its two railways, and the pensioning off of 3000 whites would probably benefit the Commonwealth finances, the average settler, and the dispossessed aboriginals. The suggestion would be perfectly feasible were it not for the patriotic and legal questions involved. The fear of "an empty north," and such problems as the aboriginals and freehold and leasehold contracts will probably continue to involve the

[1] Statistics from the Official Year Book of the Commonwealth of Australia and from Parliamentary Papers.

[2] Isaiah Bowman: The Pioneer Fringe, New York, 1932, p. 186.

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Commonwealth in spasmodic, expensive, and unsuccessful attempts to develop a delusive land.

The Commonwealth has recently extended the Central Australia Railway from Oodnadatta to Stuart in the MacDonnell Ranges, so that railhead is now 771 miles from Port Augusta. The government wished to provide a southerly outlet for cattle that could not cross the arid 5″–10″ rainfall zone, south of the MacDonnells in dry years. The extension has improved the transit of cattle and station stores, but the outlay and loss are great. In 1930 the capital cost of the whole line was £4,730,364, with the working expenses amounting to nearly twice the revenue (195.65 per cent). In 1932 the freightage of mixed goods between Adelaide and Stuart was £25 a ton. Such figures indicate the absurdity of the frequent suggestions that the Commonwealth should complete this transcontinental line to facilitate trade between southern Australia and Darwin and the Far East. Nor does the military argument have great weight when the protective zone furnished by the unbroken northern deserts is considered. Moreover the present railway to Stuart has grave military defects in the break of gauge between the main South Australian 5′ 3″ system and the 3′ 6″ of the light South Australian and federal lines.

Quorn to Stuart

After passing through the fertile wheatlands of the southern and moister sections of the South Australian highlands, the traveler enters the drier pastoral country of the northern Flinders Ranges, and changes to the federal train at Quorn. The fortnightly passenger train is well equipped with dining car and sleepers—at the cost of the taxpayers of the Commonwealth. The comfortable journey arouses speculation as to whether Australia could not have avoided a vast capital outlay and numerous breaks of gauges had she adopted uniform 3′ 6″ lines. The railway follows the old line of communication via the mound springs on the southwestern margin of the great artesian basin. The country consists for the most part of plains of red sand or red "gibber" boulders and red sand hills, carrying sparse desert vegetation in good years. Summer temperatures in this low continental area reach maxima of over 120°, and even in midwinter the noonday sun and the flies are in unpleasant evidence. Here and there are small settlements of whites, Afghan camel drivers, and aboriginals, living for the most part in poor and primitive dwellings, although the federal government has erected fairly satisfactory concrete cottages for white workers along the line. In the winter of 1932 much of the country was abandoned after a long drought. The stations were restocking, however, for a good season means some continuance of fair pasture, and the cattle are not wholly dependent

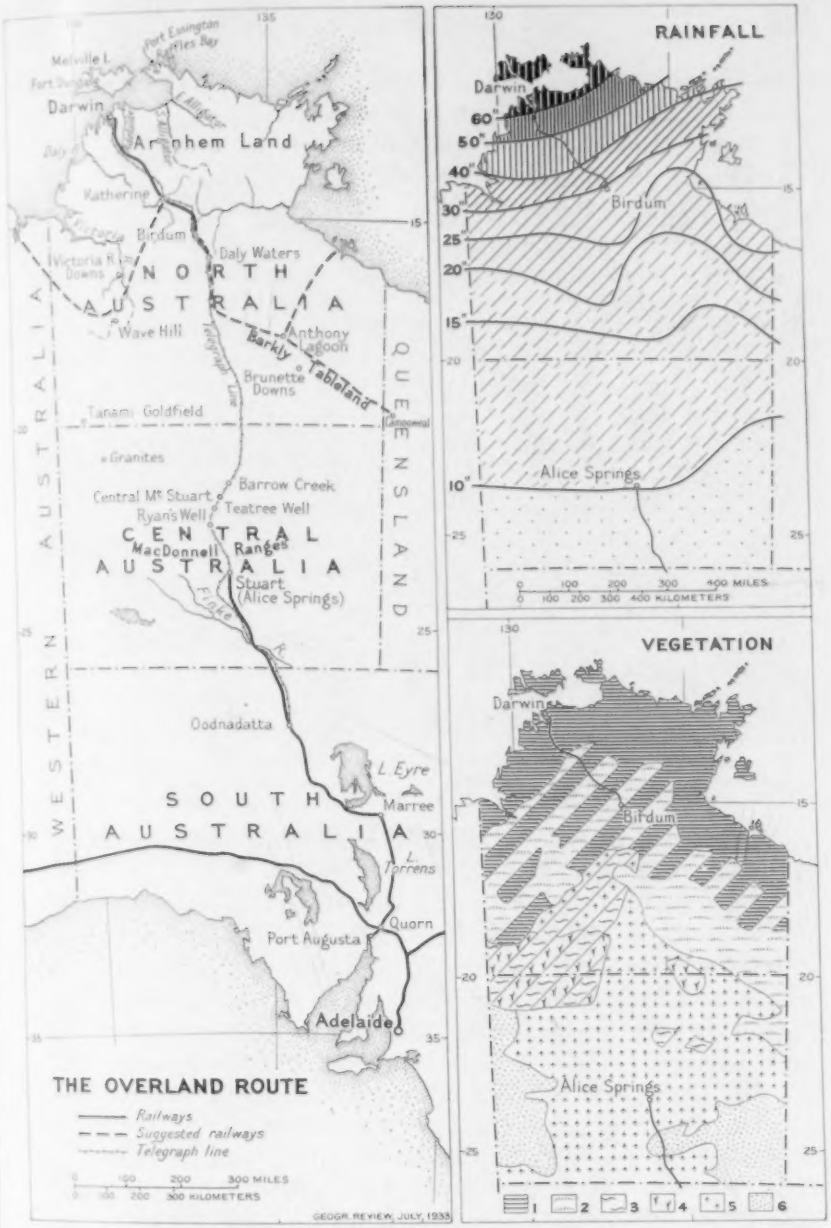

FIG. 1.—Communications, rainfall, and vegetation of North and Central Australia. The left-hand map (scale 1 : 20,000,000) shows the existing overland route. Tentative negotiations for the building of a standard gauge railroad from Bourke, New South Wales, to Birdum and standardization of the Birdum-Darwin line have recently been reported.

The upper right-hand map (1 : 24,000,000) shows the mean annual rainfall; compare Figure 9 for seasonal distribution.

The lower right-hand map shows vegetation after Prescott (see footnote 4). Key: 1, savana woodland; 2, savana and Mitchell grass; 3, mallee and sclerophyll woodland; 4, heath and sclerophyll scrub; 5, acacia semidesert and shrub steppe; 6, sand hills with desert grass.

on wells or surface water as the parachila plant, like the Texas prickly pear, contains a high percentage of moisture.

The wide sandy bed of the Finke River is crossed on a low embankment. Floods occur at intervals of years, and no effort has been made to replace the bridge that was washed away some time ago. Fences guard the track in deep sand-hill country, as the ubiquitous motorist is prone to abandon his struggle with the sand drifts and take

FIG. 2—Pool of artesian spring water in typical central-desert country, Coward Springs on the Central Australian Railway, near the southwestern end of Lake Eyre.

to the permanent way. This area is the most difficult part of the trans-Australian motor route.

The town of Alice Springs, officially known as Stuart, lies almost on the tropic at an elevation of 1926 feet in the rugged, bare MacDonnell Ranges which rise in places to heights of 4000 feet. Intermittently flowing creeks have cut remarkably narrow gorges in these ranges, and the public frequently urge that the government should build barrages to establish agriculture and improve the water supply. The soil, however, seems poor and limited in area, the rainfall averages only 10.7″ and is unreliable, and the evaporation is 95.4″ a year. Agriculture or fruit growing would be purely local, for the cost of transport under Australian conditions would prohibit export. The summer is hot, but the winter climate is clear, dry, and well suited to health resorts or sanatoria.

Stuart, like most Australian desert settlements, consists of a white township and an Afghan camp and, at a considerable and necessary distance, the humpies of the semicivilized aboriginals. The official bungalows and mission buildings are of fair design, but many private citizens live in dwellings of the most primitive kind. There is a system of pan sanitation under official supervision. This system Americans would regard as poor. Septic tanks are few. Water

lies near the surface, and we were told that for this somewhat dubious reason additional septic tanks were not allowed.

The Medical Air Service

Several religious denominations have established missions among the semicivilized natives and are doing excellent work. The Australian

Fig. 3—Camels in scrub country, Central Australia.

Inland Mission has founded a fine hospital, and the Rev. John Flynn of this body is responsible for the application of the airplane and wireless to medical service in the out-back—an experiment which may have far-reaching effects. Alfred Traeger of Adelaide perfected an inexpensive wireless receiving and transmitting set for station owners. Flynn established an initial unit at Cloncurry in Queensland, at the head of the Townsville Railway with hospital, doctor, nurses, and airplanes. The experiment proved successful. The Inland Mission is now working on a programme that will place all out-back settlers within reach of medical aid in emergency. The service has already saved many lives.[3]

From 1926 to 1931 Stuart was the Commonwealth seat of government for Central Australia, which comprises a population of some 400 persons in an area of 236,000 square miles (about the size of Texas). In 1931 the federal government replaced the region under the authority of the Darwin administration in North Australia. This seems a grave mistake. Historical tradition, past administration, and the railway have all united these central regions to South Australia rather than to North. Many of the settlers are small cattle people, whose interests and problems are utterly alien to those of the large cattle companies and socialistic labor unions of the northern lands.

[3] For details see Ion L. Idriess: Flynn of the Inland, Sydney, 1932.

FIG. 4—A Central Australian "creek." Attack Creek, where Stuart and other overland explorers had trouble with the aboriginals.

THE OVERLAND ROUTE BETWEEN RAILHEADS

North of Stuart and the MacDonnells the overland motor track stretches for 650 miles over vast level plateaus and low rocky ranges to Birdum, the head of the North Australian Railway. As far as the Central Australian boundary at the 20th parallel much of the country consists of laterite and desert sandstone, red sand or gravel plains, and red stony hills with spinifex and desert sand association.[4] The region sounds uninviting, but the lights and colors are beautiful. As in other lands the desert holds inhabitants and visitors by its own peculiar charms.

The unmade road between the railheads is passable in the dry winter season. A mail truck runs at fortnightly intervals, and an enterprising motor firm in Adelaide keeps several American cars with Australian bodies and lengthened chassis at Stuart. These take one or more parties a year to Darwin and the Daly River to shoot buffalo and crocodile. The camping outfits are comfortable, and wireless stations in South Australia keep the travelers continuously in touch with civilization. Motor breakdowns are no longer a danger. The track is a main stock route. The telegraph line can be tapped, and there are government and hand-operated wells about every thirty miles.

The dirt tracks make astonishingly good, if somewhat exciting, motoring. Creek crossings have been sloped, and sand drifts "corduroyed" by the laying down of brush and ant heap, so that the hardy North Australian settler thinks nothing of motoring three hundred miles a day. Yet despite the motor the camel still carries non-perishable commodities, halving the cost of transport though taking six weeks for a journey covered in a day by the motor truck. The train and motor mean, however, far greater comfort to the out-back settler, as he no longer has to live for months on weevily flour.

Between Stuart and the 20th parallel of latitude the route runs through very lonely country. At long intervals there are small

[4] For soils and vegetation of Central and North Australia see J. A. Prescott: The Soils of Australia in Relation to Vegetation and Climate, *Commonwealth of Australia Council for Sci. and Indust. Research, Bull. No. 52*, Melbourne, 1931. See also discussion by Griffith Taylor in the *Geographical Review*, January, 1933, pp. 108–113.

telegraph or cattle stations, such as Teatree Well and Barrow Creek. At Ryan's Well a track branches off northwestward some 300 miles to the gold fields of the Granites and Tanami. At Stuart we saw good specimens of gold from surface shows at the Granites where one of the frequent Australian gold booms has since occurred. The field is a fairly old one, but the Stuart-Granites track lies through desolate and waterless spinifex country. Wells are rare, and in some cases the water is unfit for human consumption so that the difficulties of prospecting have been severe.

FIG. 5—Light savana woodland and tropical grasses, near Daly Waters, North Australia. A member of the party is standing on the overland motor track with a dingo shot from the car.

RIGOROUS PIONEERING

The main route runs northward from Ryan's Well to Barrow Creek and Central Mount Stuart in the heart of the continent. This is a land of scattered and comparatively small cattle stations. A white man, in one case a white woman, with a handful of aboriginals will work a small station of a few hundred square miles. Most of the country is still unoccupied. In 1932, when rain had fallen, large areas looked very promising. It is, however, a country that has deceived not a few explorers and winter visitors. We were told that much of the region had been completely bare for several previous years.

In this district pioneering is rigorous and housing shocking. Comfort, amenities, and sanitation hardly exist. Here isolation blunts the senses, and time matters little. At one mail station we encountered settlers who, having forgotten the day of the week had arrived a day early. Some of the telegraph buildings are old-fashioned but are properly screened and substantial. Other stations, and the houses of the cattlemen, are mere huts of ant heap or poles with iron roofs lifted well above the walls and giving free access to myriads of flies and other pests. As one goes north one finds some rough attempts to meet tropical conditions by such devices as detached kitchens; but, even when the cattleman has made money in days of prosperity, he has provided little comfort for the white woman, apparently preferring to rely on aboriginal help.

The Lesson of the Ant

One motors mile after mile through termite country powdered with innumerable red or yellow ant heaps, which decrease in number and increase in size towards the north. This pest in itself presents a serious pioneering problem, for it ravages agriculture, horticulture, housing, and fencing. As early as the seventies the ant taught South

Fig. 6—Stuart, Institute Hall. Modern type of building on piles.

Australia a severe lesson. The colony was forced to expend the substantial sum of £82,661 in replacing with iron the wooden poles of the newly constructed Overland Telegraph line.[5] The cattleman must place his wooden buildings on wooden piles with metal cappings, which he must examine for ant corrosion; he must watch his fencing and garden; he must stand his furniture on tins above the earthen floor. From flies he can secure no protection. "Acclimatized whites" no longer heed the nuisance. They chatted to us with the flies crawling in their eyes. Cattle tick and poison weed also present difficulties. The latter seems to be spreading, but cattle can still be driven through poison areas if kept dry.

Of paramount importance in this country, as in northwestern Canada, are the police. A mere handful of splendid men, in most cases the administrators of vast areas, they travel thousands of miles a year by camel, horse, or car. They are policemen, protectors of aboriginals, inspectors of stock, and general factotums in a region of mixed population and of immense problems of miscegenation, order, and law. They give their whole life service to the Northern Territory. There is no exchange with southern areas as under the administration of the South Australian days.

Great Cattle Stations

North of the 20th parallel the track passes through Banka Banka and Powell Creek to Newcastle Waters over plateaus of gray, brown,

[5] The White Ant Pest of Northern Australia, *Commonwealth of Australia Council for Sci. and Indust. Research Bull. No. 21.*

and podsolized soils with summer rains of 15″ to 25″ which give a savana or savana-woodland association. The long winter droughts and uncertain rainfall produce low and stunted vegetation. Many of the tropical grasses are poor, though there is good grazing country with Mitchell and Flinders grasses where the road crosses the northwestern end of the Barkly Tableland. Turkey and duck are plentiful

FIG. 7—Stuart. Roman Catholic church and mission buildings. The latter is well adapted to the climate.

in this country, and the party lived on game. Tropical grasses and control by dingoes have defeated sheep experiments in North Australia, but eastwards and westwards of Newcastle Waters lie true areas of potential pioneering. These are the great cattle regions where vast stations such as Victoria River Downs, Wave Hill, Anthony's Lagoon, and Brunette Downs carry the chief North Australian herds. The number of stock rose to 970,000 in 1926, but the years of drought, closed markets, low prices, and absurd national policies cut figures by 200,000 and reduced the industry to a sorry plight. Yet in this area Australia should use her best endeavors, grant concessions from national burdens (such as the tariff, navigation acts, and industrial arbitration), open stock routes and water supplies, give generous leases to organizations with ample capital, and generally further the only industry really suited to these northern lands.[6]

THE ABORIGINAL PROBLEM

At intervals our party encountered little groups of the semicivilized aboriginals who present a grave problem. It is an interesting comment on the "White Australia" policy that the one promising industry is largely dependent on the support of this primitive and formerly despised race. If white labor unions force socialistic governments to apply white wages and conditions to aboriginal and half-caste employees, the stock owners must abandon their lands.

[6] For history and problems of cattle industry see *Bull. of the Northern Territory, Nos. 1, 8, 20*, Melbourne, 1912, 1913, 1916; for cattle pests, *Commonwealth of Australia Council for Sci. and Indust. Research Bull. Nos. 1, 2, 13*, and *Pamphlet 12;* for cattle breeds, *Pamphlet No. 27*.

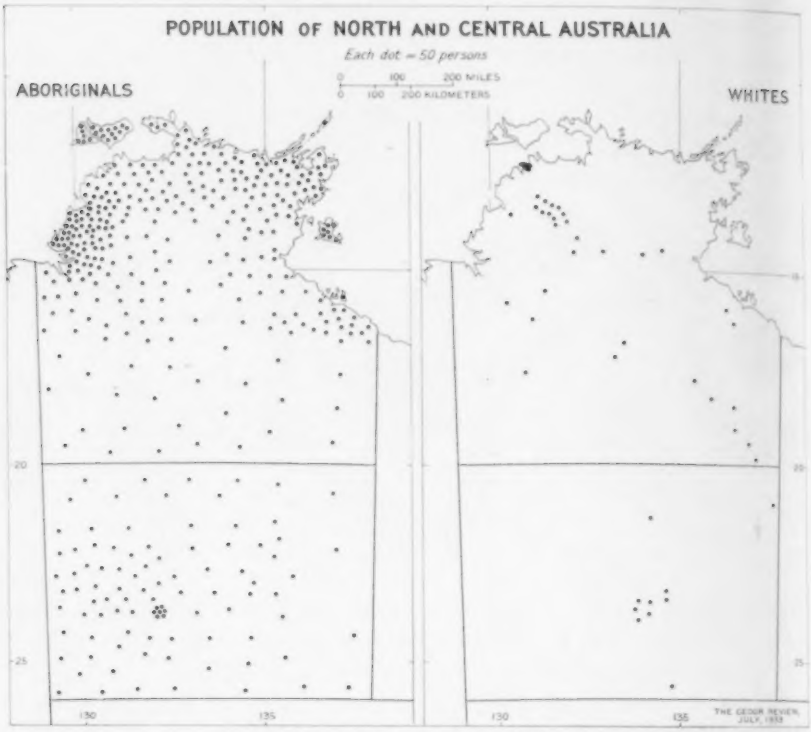

FIG. 8—A comparison of the distribution of white and aboriginal population in Central and North Australia. Distribution of aboriginals (including half-castes) is after the map (p. 671) in the Official Year Book of the Commonwealth of Australia, No. 24, 1931. Figures for the map of white population are from the census of 1921. Scale of maps, 1 : 21,000,000.

Australian scientists are urging the governments to save the wild tribes by reserving and adequately patrolling large unoccupied areas of generally unprofitable country. To their credit the federal government has already reserved Arnheimland and a large central region on the South Australian, Western Australian, and Northern Territory boundary, although these reserves are not yet satisfactorily patrolled.

In the settled areas the stations have destroyed the delicately balanced hunting civilization of the aboriginals. Here the whites collect the tribes and feed them all in return for the work of the men. This on the whole is a satisfactory policy. The cattlemen should, however, provide their stock "boys" with better quarters, and the federal authorities should increase the present miserable allotment to the old and sick for blankets and medical stores.

Miscegenation is a grave problem. The aboriginals of Australia, who possibly are not a negroid people, still number some 62,000. There are 18,000 half-castes who are increasing at the rate of about 800 a year. The North Australian authorities are adopting a far-sighted policy in regard to their half-caste aboriginals. They are

training the boys and girls in homes in Pine Creek and Darwin, marrying them amongst themselves, and finding them suitable occupations with the hope of raising them to the white level and of saving them from falling back to native camps and life. Few Australians realize how strong is the "black control" in Central and North Australia. We found certain areas still alarmed by the Cockatoo Creek murders of 1928 which drove back some of the frontier settlers.

The aboriginal, and even more his lubra, colors every phase of life in the vast territories of sparse white settlement. Despite the "White Australia" policy a great part of the continent is black Australia still.[7]

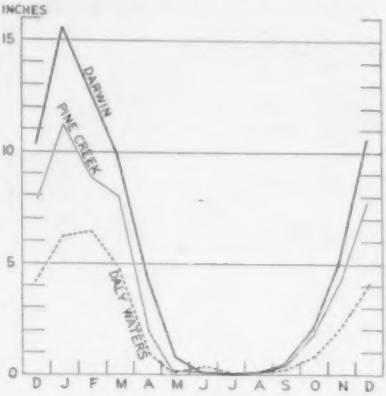

FIG. 9—Graphs showing the monthly distribution of rainfall in localities of North Australia, after Griffith Taylor. The rainfall is mainly due to tropical cyclones during the period November to March. Of Darwin's total amount of 61 inches of rain, 53 fell within this period and 24 inches of Daly Water's total of 26 inches. Pine Creek is midway between these two stations.

RAILHEAD IN THE NORTH

Birdum, the southern head of the North Australian Railway, distant 316 miles from Darwin, is a miserable township. A few shacks and an iron "hotel," with rooms divided by low partitions, constitute the place, and the hotel menu mainly consists of goat and goat's milk. One realized at once that one had entered a new and strange land.

The Northern Railway would be a comedy were it not for the tragic outlay and running losses. In 1930 the capital cost was £2,749,897, and the percentage of working expenses to revenue was 170. Freight charges are some 25 per cent higher than on the Central Australian line. The fortnightly train runs on approximately federal working hours—from 9 a.m. to 5 p.m.—with a stop of 90 minutes for lunch. The first day's journey covers a little more than a hundred miles to Pine Creek, where the passengers must spend the night in another but better iron hotel. On the transfer of the Northern Territory from South Australia the Commonwealth agreed to carry this railway across the continent from the existing railhead at Pine Creek to link up with the South Australian lines. The federal government extended the line from Pine Creek to the Katherine River, the most northerly point to which station owners could drive their cattle, as poor country with summer floods and rank grasses lies between the Katherine and the coast. The Commonwealth then continued the railway

[7] For aboriginal and half-caste question see annual reports of Government Residents of Northern Territory, and report of J. W. Bleakley: The Aboriginals and Half-castes of Central Australia and North Australia, *Commonwealth of Australia Parliament, 1929, [Publ.] No. 21.*

southward to Birdum. It suspended construction when the depression arrived. If the railway is forced farther south from political or strategic motives, the line should follow the good cattle country of the Barkly Tableland to link up with the Queensland system, and the federal government should compensate South Australia by other means. In reality no extension is necessary nor desirable. Cattle

FIG. 10—"Teatree Well" post office and station, Central Australia. The building is a typical pioneer structure—hut of poles and iron with a stone chimney.

will be driven on the hoof wherever possible, and even pastoralists who would benefit from the railway by reductions in cost of station stores themselves told us that the line would not justify the expenditure. Here the government must consider the growth of airplane and motor transportation. Air passenger and postal services are already in operation, and in the case of the east-west railway the federal authorities are already quoting "aerial and other competition" as one of the factors in their falling revenue and high costs.

MINERAL RESOURCES

At Pine Creek one finds the only extensive hill country after leaving the MacDonnells. The railway descends about 1000 feet to the coast lands by a steep plateau edge. East and west lie formerly well known and prosperous mining areas. These were rendered notorious from the seventies by a series of scandalous booms engendered by speculators and were ruined by independent Chinese miners who picked the eyes out of many rich propositions, extracting as much as £100,000 worth of gold a year. Gold, tin, and copper are promising. It is known that no deep shaft has ever been sunk in the Territory, although full information on past efforts cannot now be secured. Large companies may in time prospect the country thoroughly; but, so long as Australia refuses to admit colored workers on indenture and white labor demands arbitration wages under national policies, few organizations will dare to risk the capital required. When South Australia relinquished the Territory, the

mineral production was valued at about £60,000 a year. It has now fallen to as low a figure as £5000 a year.[8]

Agriculture in the North

The coastal lowlands, which are about 100 miles wide in this area, exhibit the effect of the 50-to-60-inch summer monsoonal rains. The

Fig. 11.—A well-known meteorological station and cattle station—Banka Banka, North Australia (about 19° S. latitude). Note the mud walls and iron roof: some recognition of tropical conditions is shown by the detached kitchen.

soils are podsolized. For the most part they carry a savana woodland association of fairly small paper bark and other gums, ironwood, pandanus palms, and rank tropical grass. There are no tropical rain forests, and jungle is to be seen only in the beds of streams.

At Katherine on the plateau and at Batchelor and other places on the lowlands are the remains of agricultural and plantation experiments. These have almost all resulted in dismal failure, owing to the uncertain monsoons, long winter drought, heavy summer rainfall, soils leached of vegetable foods, bad or expensive labor, lack of markets, isolation, cost of transport, and pests such as the white ant and rat. From 1823 to 1849 the British failed to establish agriculture in their lonely and isolated coastal stations at Fort Dundas, Raffles Bay, and Port Essington. In 1843 Crawfurd of Singapore stated that, owing to the uncertainty of the monsoon and the seasonal rainfall, he could not well conceive of a tropical region more unfavorable. In the seventies, eighties, and nineties the South Australians introduced Chinese labor and attempted to establish sugar, rubber, coffee, and cinchona on soils that were considered "rich enough to use as guano." All efforts were unsuccessful. In the words of one disgusted settler, "a more barren country God had never made." It was "doubtful if God had made it at all." The "White Australia" policy defeated attempts to bring in Tamil labor. South Australian offers to pay the passages of agriculturists were sensibly rejected by the Japanese. The Commonwealth spent large sums on experimental farms and small

[8] For statistics on mining see Administrator's reports and Commonwealth bulletins.

white blockers. With a few exceptions such as Vriborg, a Swede, who uses aboriginal labor on the Adelaide River, these have all failed.

The federal authorities have recently tried to foster the peanut industry under the usual Australian incentives—in this case the tariff and a subsidy to each grower of £1 a week. The men have

FIG. 12

FIG. 13

FIG. 12—Katharine River (latitude 15° S.) at winter level, i.e. at a low stage.
FIG. 13—Jungle in creek bed near Darwin, North Australia.

worked hard. For a time the crops were successful. Then the uncertain rainfall and poor soil brought the usual results. Soil analyses showed a lack of potash, but the government refused to supply fertilizers. The one crop industry lies at the mercy of the monsoons and of the Queensland growers who can meet the needs of the whole continent.

Even our brief examination indicated many of the difficulties. The six months' winter drought necessitates expensive irrigation. It has recently been shown that the rainfall is one of the least reliable in Australia—a view supported by history; but when the rains do come they are severe![9] The Katherine Railway bridge is some 90 feet in height, yet in wet years the floods almost lap the permanent way. Tate (1882), Lowrie (1895), and Brown (1906) took a small number of soil samples over a wide area and reported deficiencies in nitrogen, phosphoric acid, and lime.

We visited what seems the least unpromising agricultural area, the great flood plains of the Adelaide-Alligator rivers where gray-black soils cover hundreds of miles of country that is dry and caked in winter and flooded to a depth of several feet in summer. A few stations graze cattle in winter on these flood plains, but they are mainly utilized by

[9] J. Andrews: Rainfall Reliability in Australia, *Proc. Linnean Soc. of New South Wales*, Vol. 57, Sydney, 1932, pp. 95–100.

herds of wild Asiatic buffalo introduced by the British to their stations at Melville Island and Port Essington (1823–1849) and now shot for their hides. Professor J. A. Prescott of the Waite Agricultural Research Institute, Adelaide, analyzed specimens of the soils secured by us and wrote as follows:

> It is a rather heavy alluvium containing a fair amount of phosphate in the surface soil, but the potash figures are low for such a heavy soil as compared with southern Australia. Whether the soil is a true black earth or not would depend on the presence of free carbonate of lime in lower depths. It is rather like a typical black cotton soil, but would probably be most suitable for rice or for pasture production under irrigation.

It is interesting that B. T. Finniss was condemned and recalled for attempting to establish the first South Australian settlement at Escape Cliffs, on the navigable Adelaide River, commanding these plains; yet even if South Australia had utilized this soil and introduced colored labor she would still have faced the problems of transport, markets, and an immense outlay for irrigation and drainage. Today the fundamental need is that the government should suspend its agricultural expenditure pending expert soil mapping and surveys.[10]

Darwin: The Northern Gateway

The town of Darwin, the historic but delusive gateway to North Australia, occupies a healthful position on a rocky peninsula commanding a magnificent harbor somewhat hampered by tides of great range. Tropical imported trees of fine appearance line the cliffs along the water front. The official bungalows and many private residences are imposing and well designed. In view of the number of rather unfavorable descriptions of Darwin we were somewhat agreeably surprised. Like Broome and other North Australian seaports the town possesses a very mixed population of whites, Asiatics, and aboriginals, but the federal authorities have demolished the worst Asiatic dwellings and maintain a sanitary control. The town possesses such conveniences as ice and electricity. It has, however, no sewerage like the Dutch tropical cities; and, doubtless through inefficient labor, its pan system of sanitation is lamentably inferior to that of remote British stations in Burma and other parts of the Far East.

The climate is tropical monsoonal, but the winter months are not uncomfortable. During our visit the heat seemed far less trying than the winter temperatures of Rangoon or Mandalay. Many of the inhabitants dispense with headgear without ill effects. Indeed one wonders how far the climatologists can be followed in their judgments

[10] For details re attempts to establish settlement, and agriculture and other industries see references in A. G. Price: The History and Problems of the Northern Territory, Australia, Adelaide, 1930, pp. 59–67.

of Darwin and of the Queensland towns and sugar lands, where white men live, rear families, and carry on manual labor on tropical coasts. Up to the present scientists have based their conclusions largely on statistics of temperatures and humidity. Work must still be done on air movements and on other and less known climatic factors. The

FIG. 14—Katharine River post office, showing a northern type of building.

relative importance of climate, acclimatization, isolation, soils, disease, native races, and various economic factors is not yet ascertained.

A STAGNANT TERRITORY

This is the problem in the case of Darwin. The place has failed completely. It has proved a sink for expenditure, and some of the white inhabitants have behaved shamefully under the Commonwealth régime. The Northern Territory produces the worst statistics of mortality, serious crime, drunkenness, suicide, and illegitimacy in Australia; yet when one visits Darwin one feels that the climate is by no means the only difficulty, perhaps not even the most important. Isolation, mixed races, and other attributes of a poor and difficult environment are also to blame. The inhabitants of Darwin seem healthy: the mortality index of the Northern Territory for 1926–1930 was 13.48 as against 10.31 for Tasmania—a cold temperate zone. In view of the mixed population of North Australia, its huge area, and the prevalence of malaria in some inland regions the difference is not so very great. White women do their own housework or secure some indifferent help from aboriginal and half-caste labor, yet many of the native-born and exotic women appear contented and in good health. Some, it is true, are temperamentally unsuited to the conditions and make every effort to move away.

Evidence varies as regards the children. Most parents rear and educate their families in the Territory. A few send their children to temperate Australia, but fear of native influence as well as of climate may induce this. Statistics published by the health department indicate that white infants increase in weight as rapidly as those in

temperate Victoria and that boys and girls are "substantially taller" than British children of the same age, although somewhat lighter in weight.[11] The whole question of the acclimatized white manual worker in the Australian tropics presents a problem worthy of scientific examination on an extensive scale. This could be best con-

FIG. 15—Cattle station on the edge of the Adelaide River flood plains, some thirty miles east of Darwin. The main building is erected on iron wood piles.

ducted by physiologists and air-conditioning engineers in a sugar district on the Queensland coast.

The Queensland sugar areas, however, are very different from the Northern Territory coast lands where Darwin is the gateway of the pioneering country in which difficulties are supreme. The region has proved vociferous, vocal, and unproductive from its earliest days. South Australia created the nuisance by breaking her implied pledge to the British government and attempting to develop the Territory from the seacoast as an agricultural region instead of from the south and for pastoral purposes as she had stated she would do. The early inhabitants reacted to the poor environment, produced little, and demanded more and more from the South Australian government. Under federal control the region produced even less but made increasingly heavy demands. Finally it took advantage of the war to become militantly socialistic. The inhabitants secured the removal of one federal administrator by violent behavior. They forcibly deported his successor and other officials. They obtained by industrial arbitration conditions and wages that largely helped to ruin the attempts of a commercial company to make Darwin the main outlet for the northern cattle industry. The white population must therefore share with the environment and the Australian government the blame for the present stagnation.[12]

The true needs of this difficult and deceptive pioneering region

[11] Report of Administrator of Northern Territory, 1931, pp. 17–18.

[12] Report by Sir George Buchanan: Northern Territory Development and Administration, *Commonwealth of Australia Parliament, 1925, [Publ.] No. 48.* Buchanan noted that "if the young pioneer is to be paid a special isolation allowance over and above the very high basic wage obtaining in the Northern Territory, all attempts to develop the country had better be abandoned" (p. 10).

are comparatively few and simple. The Commonwealth and the outside world should recognize the clear evidence of history and geography. Almost all the central arid regions and tropics of Australia are areas of uncertain rainfall and poor leached soils remote from satisfactory markets. In the present state of scientific knowledge no race—white, black, or yellow—can find great profit in settling such lands. The Commonwealth should therefore treat North Australia as a special zone of pioneering, concentrate her attention on the cattle industry, give every inducement to private enterprise, and mitigate such national policies as tariffs, navigation acts, and arbitration—which are hopeless barriers to development. The government should recognize that the main outlets for Territory cattle lie towards Wyndham, Adelaide, and Queensland; but it might induce the reopening of the northern gateway by the guarantee of adequate concessions and a stronger industrial control. The Commonwealth should separate Central and North Australia. It should strengthen the hands of the Administrator at Darwin and grant him an advisory council with powers to spend the insignificant revenue raised from the district in certain specified ways. This might teach the citizens some responsibility and make them realize their utter dependence on outside aid. Australia should not extend her Northern Territory railways. She should not expend further funds on agriculture until her experts make proper soil surveys. She might, however, utilize a far larger proportion of the substantial sums allotted to the Territory on the aboriginals and half-castes who comprise five-sixths of the population under her care. During 1932 the Minister of Home and Territories closely examined North and Central Australia, and it is hoped that substantial changes in general policy and in the conduct of affairs will be made.

Australia will have no need to pension off the inhabitants of the Northern Territory—other than superfluous officials—if she will only ignore the unproductive coast lands and concentrate upon the productive inland savanas where the cattleman has shown the economic ability to survive discomforts, tropical climate, poor soils, inefficient labor, isolation, long transport, and pests. Here at least lies a region of actual and potential settlement upon an economic basis.

The White Australia Policy

Behind this question of the Northern Territory is the greater problem of whether the Commonwealth can develop by the "White Australia" policy or by any other policy her continental tropics of 1,149,320 square miles. Most of the conclusions of this somewhat gloomy paper probably apply to the greater part of this huge region. Temperature and rainfall are fairly well known, but the details of

regional possibilities must await further investigations such as soil surveys.

The only areas of established potentialities are patches of fertile country on the northeast coast of Queensland which receive both monsoonal and trade-wind rains. In this area, between latitudes 16° and 23½° S., the Commonwealth is attempting the remarkable experiment of extending the "White Australia" policy to the tropics by assisting the 100,000 white Australians who are carrying on hard manual labor in sugar and other industries.[13]

The results of this experiment are still uncertain. American physiologists have recently concluded that "the leisurely habits of those who live in the tropics have a sound basis of physiological necessity."[14] R. W. Cilento, Director of Australian Tropical Hygiene, considers that the Commonwealth is evolving a new type of person—the North Queensland Australian—who "moves slowly and conserves his muscular heat-producing energy in every possible way." Official records clearly prove that the white worker in the Northern Territory has certainly conserved his energy with lamentable consequences while the Australian consumer is growing impatiently critical of paying a high fixed price for sugar to support an uneconomic white industry on the Queensland coast. On the other hand, the medical scientist has greatly improved the health of tropical Queensland;[15] the white mortality index is very satisfactory, and machinery is lowering the cost of production. Of equal importance are the possibilities of improving comfort and efficiency by air conditioning, for large populations of white workers will not utilize the tropics until the standard of comfort approaches more closely that of the temperate and subtropical zones.

In summary, it seems from present indications that there is little hope for anything more than a sparse pastoral population in the greater part of the Australian tropics and that this population will show strong reactions to a poor and difficult tropical environment. There is, however, some possibility that Australians may permanently establish close settlement by white agriculturists in small and favorable areas, particularly on the east coast of Queensland.

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[13] For Queensland agriculture see reports of Commonwealth Royal Commission, 1920; Parliamentary Committee, 1931; Griffith Taylor: Agricultural Regions of Australia, *Econ. Geogr.*, Vol. 6, 1930, pp. 109–134 and 213–242; and John Andrews: Tropical and Sub-tropical Agriculture in Coastal Queensland, *Australian Geographer*, Vol. 1, 1931, pp. 62–68.

[14] D. B. Dill and Others: Physical Performance in Relation to External Temperatures, Fatigue Laboratory, Morgan Hall, Harvard University, Cambridge, Mass., 1931.

[15] R. W. Cilento: Review of the Position of Australian Tropical Medicine, *Rept. Federal Health Council of Australia*, 1931.

EXPLORATION BETWEEN THE RIO BRANCO AND THE SERRA PARIMA

Desmond Holdridge
Brooklyn Museum

THE section of northern Brazil enclosed by the Negro, Branco, and Uraricoera rivers and the Serra Parima has long been indicated on maps of Brazil as *terra incognita* and it was in the hope of finding there aboriginal cultures unchanged by contact with white men that the writer's expedition was undertaken. During the seven months from May to November, 1932, explorations were conducted on three of the five large tributaries of the Amazon system that have their sources in the Serra Parima—the Catrimany, Deminí, and Aracá.[1]

Throughout the several journeys low mountains at strategic points were ascended and bearings taken from them on near-by and distant peaks and sketches made. The resulting network of bearings constitutes a rough triangulation of the whole region and with the photographs and sketches has made possible the construction of a map giving an approximate representation of the topography. A part of the Brazil-Venezuela boundary, following the crest of the Serra Parima, lies within this area, and as a consequence its delineation will be quite different from any shown heretofore.

The Rio Catrimany

The first river to be explored, the Catrimany, we entered on May 23 with two large canoes and a crew of twelve men, intending to follow the river to its supposed source in the Parima Range and, if possible, to cross the range to the headwaters of the Orinoco.

The Catrimany was first explored in 1787 by Manoel de Gama Lobo d'Almada, Portuguese governor of the Capitania do Rio Negro, who ascended it as far as latitude 1° 49′ N. and made a map based on astronomical determinations of latitude and longitude from which all subsequent maps of the river have been copied. In recent years the river has become well known for a considerable distance to balata bleeders, who usually enter it early in May, at the beginning of the rainy season, and come down with their cargoes in October, when the rains ordinarily end. The fall in the price of balata due to present economic conditions, coupled with an attack on the *balateros* of the

[1] On the two trips up the Catrimany River the writer was accompanied by Emerson Smith of Wiscasset, Maine. Later Smith made a trip up the Rio Negro.

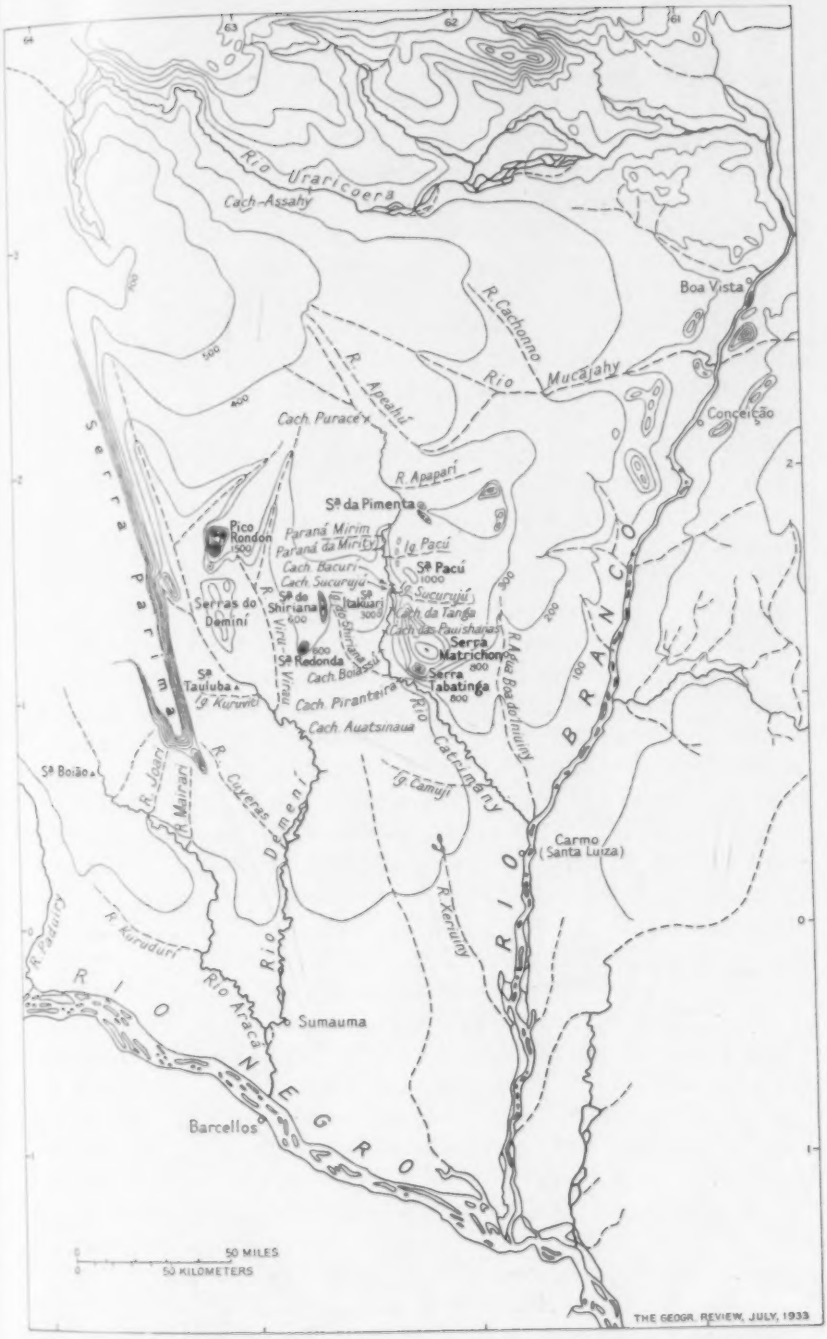

FIG. 1—Map of the region between the Rio Branco and the Serra Parima incorporating a preliminary compilation of Holdridge's surveys and elevations. The Negro, Branco, and Uraricoera rivers are from surveys by Dr. Alexander Hamilton Rice. Elevations and contours are in meters and are approximate only. Scale approximately 1:3,600,000.

region by Pairitiri Indians in 1926, has, however, virtually stopped the balata bleeding.

The only civilized habitation on the river is that of a negro who lives in a hut six miles above its mouth, and it was not until we had been ascending the river for ten days that we came upon the first Indian habitation, a *maloka* on the east side of the river occupied by ten semicivilized Pauishanas who speak some Portuguese and are the remnant of what was formerly a fairly large group.

The Catrimany is a white-water river: reports to the contrary evidently have come from persons who have only passed the mouth of the river, across which sweeps the very black water of the Rio Agua Boa do Iniuiny. White-water rivers, it may be noted, flow through regions of sand and clay, and it is the sediments of these held in suspension that give rise to the turbid, yellowish color. The black-water rivers usually flow through a granite or sandstone terrain, and the color of the water is to be attributed to the action of mineral salts on particles of vegetation held in suspension. The *igapo*, or flooded forest, is a characteristic feature of the white-water streams.

When we entered the Catrimany in May it was very nearly at its peak, whereas we had found it to be at dead low water when we passed the mouth in March. Almost everywhere in the *igapo geral* of the river below the first rapids the banks were flooded, and it was frequently very difficult to find a suitable camp site. Mosquitoes were not numerous and anopheles were rare; nevertheless a mild form of malaria made its appearance on several occasions, although never to such an extent as to be a serious handicap. The greatest drain on the efficiency of the party was caused by leg sores, a common affliction between the Rio Branco and the Rio Negro and the most serious single menace to health in that region. There seemed to be a definite relation between the leg sores and the number of piume flies.

The Catrimany maintains a width of about 200 meters from its mouth to the Cachoeira Piranteira, the first rapid and the limit of possible navigation by steam vessels. Craft drawing up to eight feet could easily ascend to that point in the wet season. The number of dangerous cataracts is then not large, but in the dry season they become exceedingly difficult to negotiate. The first troublesome rapid that we encountered was the Cachoeira Boiassú, a mile-long stretch of falls, rapids, and fast water; Cachoeira da Tanga and Cachoeira das Pauishanas also proved difficult in spite of the high water; but it was the Cachoeira Bacurí that presented the greatest obstacles. A whole day was spent in passing it and its twin, Sucurujú. Our difficulties in the rapids were increased by the presence of numerous wasp nests; for the canoe men have the not unreasonable custom of slacking the bowline and jumping into the water when attacked by these pests.

Ridges and Peaks Seen from the Catrimany

We had sighted our first mountain some distance above the mouth of the Igarapé Camují—a sharp peak about 800 meters high now called Serra Tabatinga but corresponding to the Serra Amariaki of Lobo d'Almada's map. From the Cachoeira Bacurí we had an excellent view of Serra Pacú, a 1000-meter mass bearing 45° and close to the left bank of the river. From the Cachoeira da Tanga could be seen the Serra Matrichon, a long mountain mass on the left bank of the Catrimany about the same height as Tabatinga and running from north-northwest to south-southeast. Directly opposite, on the west side of the river and about four miles from it was an isolated, 300-meter peak, Serra Itakuari (Itaqueu on the Lobo d'Almada map). We cut a trail to the top, whence we commanded a wide view from southeast through south to north-northeast.

From west-northwest to north-northwest numerous peaks and ridges could be seen. None of our crew was able to name any of them, having been previously unaware of their existence. The most conspicuous object was a mass crowned with high cliffs whose highest point bore 291° from our position. I estimated its distance from the summit of Itakuari as 45 miles and its height as 1500 meters. Conversation with the mestizos of the Rio Branco and Rio Negro, as well as careful examination of existing maps, convinces me that it has never before been reported. I shall hereafter refer to it as Pico Rondon for General Candido Rondon, the noted Brazilian explorer. Behind Pico Rondon we could see the Serra Parima, a long wall of even height that reached considerably farther south than has been previously supposed. At no point was there a visible break in the range. Our photographs of it, taken from Itakuari, very nearly connect with Dr. Alexander Hamilton Rice's photographs taken from an airplane over the Cachoeira Assahy on the Rio Uraricoera.[2]

Between Itakuari and the Serra Parima and apparently immediately south of Pico Rondon was a low range extending from west to west-southwest. This also has not been previously reported, and I shall refer to it as the Serra do Deminí since the Rio Deminí cuts through it. About 30 miles to the southwest there was a solitary 600-meter mountain, which I called Serra Redonda from its shape. From 20 to 25 miles due west was a low mountain of about the same height, which may well be called the Serra do Shiriana since the Rio Shiriana has its source in it. To the northwest we could see several flat-topped mountains 30 to 40 miles away. In the same direction but close at hand were low, rounded mountains. To the southeast the Serra Tabatinga, first sighted a short distance above the mouth

[2] A. Hamilton Rice: The Rio Branco, Uraricuera, and Parima. *Geogr. Journ.*, Vol. 71, 1928, pp. 113–143, 209–223, 345–357.

FIG. 2—View east and southeast from a low hill at 1° 26′ N., 62° 24′ W. of the mountains east of the Rio Catrimany. The peak at the left of the photograph is Serra Pacú.

of the Igarapé Camují, was again visible, and it was at once clear that it was not an isolated peak but merely a knob on a long range whose southern end was shut off from our view by the dense forest on the summit of Itakuari. To the south a flat and utterly featureless forested plain stretched away to the horizon.

CAMP OF BALATA GATHERERS

A short distance above the Igarapé Pacú, a black-water stream about 20 meters wide, we came upon the last of the camps of the balata bleeders, where a party of twelve mixed bloods was working. They reported that the Uaiká Indians were around the interior camp but were confining themselves to a teasing campaign that consisted in hiding near a man high on a balata tree and shaking the branches of low bushes. The psychological effect of being watched by savages, of whom nothing more than tracks was ever seen, was apparent in the low morale of the party. The Igarapé Pacú is now the farthest point visited by the balateros, and it is doubtful whether they will ever again go so far on account of their distrust of the Uaikás.

The Catrimany, during the ten years in which it has been exploited by the balateros, has been the scene of a number of Indian attacks, and each attack has been followed by the withdrawal of white men and mixed bloods from a section of the river. In most of the cases brought to our attention it seemed evident, however, that the balateros had provoked the attacks. These encounters between the balateros and the Indians sadly upset our plans, for we had counted on the Indians' knowledge of the country and the use of their trails and bridges in our proposed exploration of the region.

We climbed a rocky hillock a short distance from the balata camp and took bearings on and photographs of the mountains visible to the east. To the northeast was a high, round mountain, called Serra da Pimenta by the balateros, which forms the northern end of the range occupying the triangle formed by the Branco, Catrimany,

FIG. 3—Continuation southward of Figure 2. The slender pinnacle at the left is Serra Tabatinga; the sharp peak a little to the right of the center, Serra Itakuari.

and Mucajahy rivers. Serra Tabatinga forms the southern extremity of the range. Far to the east we recognized a mountain which we had already seen from Caracarahy on the Rio Branco and which Rice reported as bearing 247° from Conceição on the same river.[3] The triangle formed by the lines connecting these points is filled with more or less continuous ridges, peaks, and bluffs, whose character and relative positions are best understood by reference to the accompanying map.

From the balata camp we continued on up the river by way of the Parana da Mirity—a three-mile, rapid-choked side channel—rather than by the even more encumbered main river. Two days were spent in getting through the Parana da Mirity and one day in the Parana Mirim. The upper end of the Parana Mirim marks the end of the first cataract-obstructed section of the river, and, having passed through it, we were once more in the igapo geral with its peculiar vegetation and its numerous and varied pests. The piume flies, which had disappeared in the rapids, reappeared unequalled in numbers and voracity. The leg sores that had closed reopened, and those that had failed to heal grew worse. Meanwhile the paddlers were increasingly uneasy on the subject of Indians, and game became scarce.

RELATIONS OF THE UPPER CATRIMANY

On June 24, a month after leaving the Rio Branco, we arrived at the confluence of the Catrimany and the Rio Araparí. This is the farthest point reached by Lobo d'Almada and was called by him Repartimiento. From Repartimiento on we were in completely unexplored country, although it was generally supposed that the upper part of the river flowed in an easterly direction from sources in the Serra Parima, making a sharp bend to the south a short distance above its junction with the Araparí. We were soon enlightened, however, for, after a short east-west section, the river resumed its

[3] *Ibid.*, p. 123.

north-south course. Its width varied between 5 and 40 meters with stretches nearly 100 meters wide dammed by shallow sand bars.

Food and ammunition being now very low, we resolved to push on until both were entirely exhausted and then trust to a swift descent through the rapids to the Pauishana maloka where vegetables and fruit were to be had. On July 1 our resources gave out at the Cachoeira Puracé in latitude 2° 11′ N., longitude 63° 25′ W. From the rate at which the river narrowed I should estimate its source to be some 30 miles farther north or northwest. The Pauishanas say that there is a large fall not far above the Cachoeira Puracé and that a short distance above it a sizable creek enters the river from the west. According to tradition, the source of the Catrimany is in a large pool with a low sand bank on its eastern side. Turtles crawl from the pool over this sand bar and drop at once into the source of the Mucajahy or its affluent, the Apeahú. It is also said that a half-day's walk east of the Cachoeira Puracé there is a large tributary of the Mucajahy, probably the Apeahú. The Pauishana headman told us that he formerly lived on the Rio Araparí, which is a small stream in spite of its wide mouth, and that, at a point two days' paddling up the river from its mouth, the Pauishanas were accustomed to leave their canoes and walk overland for one day to the Apeahú, which they would descend to the Mucajahy, the seat of the tribe and my informant's birthplace. The conformation of the mountains on the east bank of the Catrimany seems to bear out his statements.

Our discovery that the Catrimany flows south from at least as far north as 2° 11′ N. reduces the importance of the Mucajahy. It also makes possible the Indian story that there is a *furo* between the Mucajahy and the Uraricoera that is navigable by canoes in the rainy season.

The descent to the Pauishana maloka was made without incident, the main river being followed instead of the Parana Mirim. The large rapid that is avoided by using this side channel is the Cachoeira Duarte of the Lobo d'Almada map. The Pauishanas having agreed that some of them would help us search for the Uaiká maloka, where we hoped to secure help in reaching the Parimas, we descended to Manaos to overhaul our motor boat.

On August 8 we again ascended the river to the Pauishana maloka and left the motor boat there, for the river had fallen so low as to make the rapids impassable to anything but a canoe. On this trip the canoe was crewed by three Pauishanas and an Arekuna from the highland savanas of southeastern Venezuela whom I had brought down to Brazil in 1930. The elimination of the mixed bloods from the party was an enormous advantage. The Indians were better canoe men and harder workers. Moreover, there was none of the bickering and the flourishing of knives that characterized the first ascent.

All of the cachoeiras had been transformed into dangerous falls except Bacurí, which was appreciably less difficult than on our first ascent. Six days after leaving the maloka we reached the balata camp above the mouth of the Igarapé Pacú to find the balateros just about to leave. They reported that no signs of the Indians had been observed for weeks. Leaving the river we worked westward for two days and then made a camp from which we scoured the forest for long distances in various directions; but a week of continuous searching yielded only blazed hunting tracks that invariably disappeared when followed for any distance. We decided, therefore, to ascend the Rio Shiriana to its source and from there make a similar search to the west.

The Rio Shiriana

The Shiriana proved to be a much pleasanter stream than the Catrimany, since it was without insect pests and fish and game were plentiful. On the morning of the fifth day, however, the river suddenly divided into two branches, which, in turn, divided into others until we found ourselves forced to cut a passage for the canoe through thick growth that interlaced across the narrow channels. A half day of experimenting with various tiny channels convinced us that we were in an enormous igapo geral, a suspicion confirmed when we returned to our last camp and climbed a tall tree. Due west, however, and about five miles away was the Serra do Shiriana. Several exploratory trips were made from this camp, but we found no trace of the Uaikás. An attempt to reach the top of the Serra do Shiriana failed because of the difficulty of making progress through the flooded forest. We now decided to ascend the Deminí and therefore returned to the Pauishana maloka. After a trip to a large stretch of *campina* several miles west of the maloka from which we were able to get bearings on and photographs of Tabatinga and the adjacent mountains, we brought the motor boat around to Barcellos, a small village on the Rio Negro opposite the mouth of the Aracá.

The Rio Deminí

The Aracá and Deminí rivers have been exploited by mestizos of the Rio Negro for many years. The Aracá has supported a small population with ita piassava fiber, and the Deminí has been worked for rubber and Brazil nuts in its lower reaches; but the high rate of mortality from a peculiarly malignant form of malaria endemic on the latter river has prevented either industry from attaining any importance. Health conditions on the Deminí have improved slightly since the great fires of 1926; but it is still decidedly unhealthful. Malaria, leg sores, digestive troubles, and eye diseases are very common. Mosquitoes are numerous and the commonest form is the

anopheles. The civilized population of the Deminí does not number more than two hundred persons, who live by fishing and the gathering of Brazil nuts, and is centered in the little settlement of Sumauma and a number of *sitios* all located within ten miles of Sumauma but in no way dependent on it. The civilized settlements of the Aracá were the scene of a spirited attack on September 24, 1931, by Indians

FIG. 4—Serra Pacú from the Cachoeria Bacurí.

of an unidentified tribe. The settlements comprised nearly a hundred persons; but they were greatly outnumbered by their assailants, and, though seven Indians were killed, two women and a child were carried off. It seemed possible that the Indians might have been Uaikás.

We entered the Deminí on October 6 and ascended it as far as Serra Tauluba in latitude 1° 05′ N., longitude 63° 02′ W. For some distance above its mouth the Deminí ranges in width between a third and a quarter of a mile. The water here is black but the color is to be attributed to the Rio Cuyeras, a tributary about 50 meters wide that enters from the west. Above the mouth of the Cuyeras the water of the upper Deminí is white and exhibits the peculiarity of growing lighter and clearer as its source is approached.

VISIT TO THE UAIKÁ INDIANS

Immediately above the first rapid, the Cachoeira Auatsinaua, there is a maloka of Shiriana Indians who are in contact with the civilized population farther downstream and some of whom speak a little Portuguese. The chief maintains trade relations with the Uaikás of the forests of the upper river and agreed to guide us to their first maloka, three days farther upstream. On the afternoon of the third day we arrived at the Igarapé Kuruvití, on which the maloka is situated. The Kuruvití, also a black-water stream, is ten meters wide but is so encumbered with fallen logs as to be impassable even

for canoes. Leaning against a fallen tree near its mouth was a newly cut fishing pole. A little farther on there were fresh tracks in the sand, and not far away an opening in the forest wall announced the trail to the maloka.

The motor boat was tied up on the opposite side of the river, and we proceeded along the well-marked trail. At the urgent behest of

FIG. 5—A view northward from Serra Tauluba of the Serras do Deminí.

our three Shirianas, all were armed. Within fifteen minutes the trail led across a small bridge over a dry brook bed and then through a banana patch. We soon crossed another banana patch, and immediately thereafter the low hum of human voices was heard. The Shiriana who led the party stopped and ordered us to fire one shot each and then follow him into the maloka at a quick trot. The sound of the volley was followed by a burst of savage yells, and almost at once we were confronted by ten naked bowmen. They were larger than most Indians and somewhat lighter in color than the ordinary forest Indians. The crowns of their heads were shaven and painted red as had been those of the Indians killed in their attack on the civilized settlements of the Aracá River. On seeing the Shirianas they wheeled and ran through the several doors of their huge maloka. We followed them in.

When our eyes had become accustomed to the gloom of the great structure we discovered that every man was in his bark hammock with his bows and arrows beneath. They were very suspicious, and their chief said so at once. The long explanation of our presence delivered by the Shirianas was finally accepted, and we were led to a great trough of banana stew and invited to eat. Later the men came down the river, and cloth and steel instruments were distributed among them. Our purpose in visiting the country was explained, maps and photographs were displayed, and Umiasu, the Uaiká chief, allotted three men to cut a trail for us to the top of Serra Tauluba, a low mountain two miles away.

At daybreak the next morning the three men arrived as promised, and the entire party climbed the 300-meter hill. From a rocky knob on its summit the horizon from southeast through north to west was visible: to the northeast were the Serra do Shiriana and the Serra Redonda; due north was Pico Rondon. We realized that we were on a summit of the Serra do Deminí that we had seen against the wall of the Parimas from the top of Itakuari. The mountains northwest and northeast of Pico Rondon did not show through the mist, nor did the Parimas. After taking photographs and bearings on everything visible we returned to the maloka and attempted by tactful questions and offers of ransom to discover the whereabouts of the two women and the child who had been carried off during the attack on the Aracá settlements. Umiasu pointed west-southwest and counted ten days of overland travel to the maloka where he believed they were held but said that he could not treat for their release or guide us to the place because he was at war with the tribe.

One of the women in the Uaiká maloka was a Pairitiri, a tribe closely allied to the Uaiká. I believe that the savages encountered by Rice at the head of the Uraricoera were not Shiriana, as he surmises, but Pairitiri, for his description tallies exactly with the appearance of the Uaiká and of this Pairitiri woman and Pairitiri men of whom we have heard. Furthermore, the word *puca*, which Rice says the Indians of the region called a certain rapid on the Alto Parima, is a Uaiká and Pairitiri word and means simply a rapid. In the Shiriana tongue the word has no significance as far as I could learn.

Specimens of the low material culture of this group were obtained by barter, names of neighboring tribes recorded, and some geographical information gathered. We were told that the Deminí flows from the northwest and has several affluents as I have indicated on the accompanying map. It is highly probable that the source of the river is near that of the Parima.

The Rio Aracá

Since the Deminí was falling rapidly we left the *maloka* on October 21 and descended to Barcellos, where preparations were made to ascend the Aracá. The Aracá is a black-water river but otherwise is much like the Catrimany and the Deminí, with the same winding course. We found the river so low that the sandstone bed twenty feet below the surface of the soil was exposed. The most remarkable characteristic of the region through which the Aracá flows is the thinness of the vegetation that grows in its sandy soil. We suspected from this that we might find open campo to the north, as proved to be the case.

The width of the river up to the mouth of the Rio Mairari ranges between 300 and 400 meters. Above that point it narrows rapidly

until at Boião it is only fifteen meters wide, while above the first fall it is so narrow that it is necessary to cut a passage for canoes. As along the Deminí and the Catrimany, numerous lakes, some of considerable size, open into the river. The first tributary, the Rio Kurudurí, is a black-water stream twenty meters wide, which rises in the northwest in the vicinity of the Paduiry. This is attested by the journey of a piassava gatherer who, in fleeing from his *patrão* on the Paduiry, lost his way and came out on the Kurudurí.

A short distance above the mouth of the Kurudurí the campinas of the Aracá begin, and farther on there is the Campo da Limão. We explored this campo for a short distance to determine its fitness for cattle. The grass, in the main, was of the type known in Brazil as *tiririque:* a season's burning would have converted it into excellent pasturage. Fat, sleek deer abounded, and near the islands of scrubby forest tapir tracks were numerous. The campo ran northeast, interrupted here and there by islands of forest, and our surmise that it continues to the Deminí was later confirmed.

On November 19 we reached the Serra Boião, a granite hill rising 73 meters above the river and distant from it three miles. The forest here was very thin with the piassava palm predominating. From the summit of Boião we had a good view in all directions. The Serra Parima, known at this point as Tulu-Tuloi—a Bufuana word—filled the horizon from east through north to northwest where it disappeared in the haze. The range was a sheer wall of what appeared to be sandstone cliffs. The valleys of several rivers that we had passed could be distinguished and also the valley of another river entering the Aracá above our highest point. To the west we could see the hills along the valley of the Paduiry. To the south and southeast the country was a flat, featureless plain. Everywhere, as far as we could see, the land was forested.

We went on up the river to a point near the first rapid and then returned to a low cluster of granite rocks. From these on a clear day we had another view of the not-far-distant Parima Range. Bearings were taken on prominent points on the crest of the range and the intersections of these bearings with those taken from Serra Itakuarí served to fix with a fair degree of accuracy this previously unexamined side of the range. As we have pointed out, both the position of the range and the outline of its crest—and consequently the course of the Brazil-Venezuela boundary that it carries—are different from previous representations.

Campos and Cattle

Between us and the Parimas was a continuous campo that stretched to the Deminí. The courses of the Rio Mairari and the Rio Joari could be seen and also the probable source of the Rio Cuyeras. I

strongly suspect that this point marks the end of a more or less continuous campo that extends from Carmo on the Rio Branco to the very foot of the Parimas. Coronel Bento Brazil has put cattle in the campo back of Carmo and has explored it west as far as the sources of the Xeriuny. Along the Yufary River and also along the Igarapé Camují there are large campos. Between the Demini and the Yufary lost Brazil nut gatherers have come out on open grassland, and from our observation point it was clear that the campo extended to the Deminí.

Persistently burned over for several seasons and stocked with Rio Branco cattle, these campos might become of economic value to the impoverished state of Amazonas. On the Rio Negro a regular supply of fresh meat would greatly improve the health of the inhabitants, to say nothing of providing a source of livelihood, for, since the collapse of the rubber market and the Brazil nut and piassava industries, the people of the region have lived on the verge of starvation.

EXPLORATIONS IN SOUTHEASTERN GREENLAND

PRELIMINARY REPORT OF THE SIXTH AND SEVENTH THULE EXPEDITIONS

Knud Rasmussen

THE Sixth Thule Expedition, a reconnaissance along the southeastern coast of Greenland, owes its successful accomplishment to the unusual conditions that obtained in 1931. Practically speaking, there is no open season along this ice-blockaded coast. A hundred years ago it took Graah three summers and two winters to force a passage to Dannebrog Island; fifty years later Holm and Garde took the same time to reach Angmagssalik—the only expeditions to carry out systematic scientific exploration on this coast.[1] In 1904 as a member of Mylius Erichsen's Literary Greenland Expedition I was one of those who attempted a coastwise journey. The attempt failed, but at Qernertormiut, east of Cape Farewell, I came across a camp of East Greenlanders with whom I lived for some time. While with them I collected so much geographical and ethnographical material on Frederik VI Coast, as Graah had named it, that I then and there determined to make my contribution to its exploration. But the ice held sway. I carefully followed the official ice reports from that coast, supplementing them with no less important reports from the Greenlanders at Cape Farewell and the Angmagssalik district. At last the opportunity came. In 1931 I decided that a reconnaissance trip was possible. And so it proved. This ice-besieged coast was navigable from the beginning of July and in August and September was so free of ice everywhere that there was unhindered navigation for motor boats and fair-sized vessels.

Course of the 1931 Expedition

In contrast with previous expeditions, which had used umiaks, I chose a good seagoing boat with a powerful motor, and I had a crew experienced in seamanship.[2] The start was made from Julianehaab on August 19. On August 22 we arrived at Lindenow Fiord. There we established an archeological station in charge of Erik Holtved

[1] Nansen passed along the coast from Anoritoq to Umivik in 1888 for his crossing of the inland ice. His account of the difficulties of the ice belt and attempts to penetrate it is well worth consulting in this connection.

[2] Knud Rasmussen: South East Greenland: The Sixth Thule Expedition, 1931, from Cape Farewell to Angmagssalik, *Geogr. Tidsskrift*, Vol. 35, 1932, pp. 169–197.

and two Greenlanders. Leaving the fiord, we at once set out full speed northwards for our next special area, the net of fiords round about Skjoldungen Island. Outside the various inlets, especially Anoritoq, we fell in with a good deal of calf ice, but there was no field

FIG. 1—Map showing the distribution of ancient Eskimo settlements between Qegertaulaq and Aluk, based on observations of the Sixth Thule Expedition and on data furnished by Eskimo hunters.

ice. On the way we went in to see the notorious glacier Puisortoq. After a brief sojourn at the old settlement in Tingmiarmiut, we reached Skjoldungen Island on the evening of the 24th and entered the northern arm of the fiord with Dronning Maria Valley as our goal. There we met two Norwegian hunters, members of Finn Devold's hunting expedition.

Various tasks engaged us for an entire week in Dronning Maria Valley, whose Eskimo name is Eqalungmiut—a fertile, blossoming, and thicketed valley, lying oasis-like in the midst of calving glaciers and wild alpine heights.

On the evening of August 30 we sailed out of the fiord, steering round the landward side of Umîvik, where we knew that two East

Greenland umiak crews had some land, though we did not find them at the place indicated. At noon on September 1 we were at the trading post—the first motor boat to navigate the stretch from Cape Farewell to Angmagssalik. We visited one or two settlements up the fiord, where we filmed some of the games and drum dances, but the season was advancing, and on September 6 our bow was headed for Umîvik, where we found the settlement missed on the way up. Here in one house lived seventeen people. They told us that in the fog we had sailed past a settlement twice as large at the head of Köge Bay. Altogether, more than a hundred people live south of Angmagssalik and Sermilik Fiord, mostly people who had been accustomed to moving about in these regions until the mission was started at Angmagssalik and attracted them to it. Now that they have all been baptized and the young have learned to read and write, they are moving back to their old hunting grounds, arranging matters the while so that some man or woman at the settlement undertakes the educational duties on week days and divine service on Sundays. Their hunting district and their winter dwellings extend down to Tingmiarmiut. Here at the settlement of Patsajuk we were strongly impressed by the favorable hunting conditions offered by these coasts to Eskimos who have kayaks and umiaks. The people had large stores of seal meat, and all radiated prosperity.

Unfavorable weather now set in. Gale followed gale, and we had to be content to carry out our work where conditions permitted. On October 1 we rejoined our friends in Lindenow Fiord and next day arrived at the post called Augpilagtoq, in the Julianehaab district.

Results of the Sixth Thule Expedition

The results of this reconnaissance expedition may be briefly recounted. At the archeological station in Lindenow Fiord Holtved excavated and examined 25 houses, securing a collection of more than 2000 specimens for the National Museum. By revealing the localities likely to furnish the most profitable results, various scattered archeological surveys made north of the fiord were of great assistance to the work done the next year.

Most important was the magnetic work carried out by Johannes Olsen. At 18 stations observations were made of magnetic variation, magnetic intensity, and inclination: among other records about 4000 variation observations were made at Angmagssalik, Skjoldungen, and Julianehaab. As a result the part of East Greenland traversed by the expedition has been better charted magnetically than any part of the west coast of Greenland of corresponding size. That these magnetic observations were made in the year prior to the Polar Year 1932 gives them an added importance.

FIG. 2

FIG. 3

FIG. 2—The edge of the ice-cap at Auarqat Fiord, southeastern Greenland.
FIG. 3—Marginal mountains with glacier arms behind Anoritoq.

FIG. 4

FIG. 5

FIG. 4—Dronning Maria Valley and Eqaluit, a salmon river, at the head of Skjoldungen Fiord.
FIG. 5—A glacier entering the northern arm of Skjoldungen Fiord.

The cartographic work was in the hands of Commander Bangsbøll. The inner part of Skjoldungen Fiord, especially of the northern arm, was triangulated, and sketches were made of a number of good harbors and anchorages; otherwise, in consequence of the reconnaissance nature of the expedition, the survey had to rank second to navigation,

FIG. 6—The interior of Skjoldungen Island, seen from above the northern arm of the fiord.

for the experience of navigation in these waters gained on the Sixth Thule Expedition was prerequisite to the success of the Seventh Thule Expedition.

THE SEVENTH THULE EXPEDITION, 1932

It was on the basis of the 1931 reconnaissance that the Seventh Thule Expedition could be planned and carried through. Where once a few isolated umiaks battled their way through the breakers and ice of that deserted coast, seven large and small motor boats, besides the expedition ship *Th. Stauning*, and a seaplane were all foregathered. Members of the expedition numbered 62, of whom 25 were Greenlanders, most of them with kayaks.

Our task was a complete exploration—topographical, geological, and archeological—of the stretch from Umîvik to Cape Farewell. It is a distance of about 600 kilometers as the crow flies, and the program had to be completed in the brief space of two months. Now it may be that a distance of 600 kilometers does not sound very impressive, but this wild, indented coast has more than fifty large and small inlets and sounds. Altogether our motor boats traveled some 20,000 kilometers, and the seaplane in 125 flying hours flew about the same distance. If to this we add the course of the *Th. Stauning* within the

expedition's area, the sum total of our journeys corresponds to a voyage round the world.

As it was impossible to secure a large enough ship the expedition had to proceed to and from Greenland in relays. I was the first to

FIG. 7—Kagssortoq Fiord in southeastern Greenland. Altitude of the plane, 3000 meters.

go, partly for the purpose of making a personal selection of the many Greenlanders needed and partly to assume the protectorate for Dr. Fanck's large film expedition to North Greenland. I had therefore to rest content merely to be present at the start of the long motor-boat journey from Julianehaab to the East Coast in the last days of June with Captain Gabel-Jørgensen in command. I rejoined the expedition in Skjoldungen Fiord in the beginning of August. Dr. Therkel Mathiassen was fetched from Angmagssalik, and on August 11 we were all gathered together, with good preliminary results, at Graah's winter quarters in beautiful Imarsivik. The next day we split up again, some going north, others south, to new tasks along the coast. Only the *Th. Stauning* remained at Imarsivik with the seaplane crew.

The chief task was cartographic work from the air with Captain Gabel-Jørgensen, the second-in-command of the expedition, in charge, assisted by Lieutenant Erik Rasmussen. The aerial mapping proceeded from six bases, with the *Th. Stauning* as mother ship, for which purpose she was ideal. Thanks to good weather and favorable ice conditions and particularly to skillful handling, the East Greenland flight program, which comprised the whole stretch from Pikiutdleq, north of Umîvik, down to Cape Farewell, was carried out with almost mathematical precision at the times arranged and, on September 2, was concluded with a flight from Lindenow Fiord over the southern part of the ice cap direct to Julianehaab. A total distance of 11,000 kilometers—corresponding to twice round Greenland—was covered on the surveying flights, and about 1000 aerial pictures were taken.

The photography was continued on the west coast as long as the weather permitted, and here were included the areas where Professor G. Hatt and Dr. Poul Nörlund were carrying out their extensive archeological investigations. In sum, of the 81 days there were 41 flying days with about 100 flights.

Mention may also be made of the flight to relieve the Hutchinson family, when Lieutenant Erik Rasmussen in one stretch flew from Ivigtut over the ice cap to the Norwegian station Finnsbu north of Skjoldungen, returning in a northerly gale after the news of the Hutchinsons' rescue had been received by wireless. Putting all the flights together, the Danish Navy's seaplane 84 has made a record for flying in Greenland—19,000 kilometers in a single season by a single machine.

From the comprehensive material we brought home, a new map will be drawn by the Geodetic Institute in Copenhagen, under the direction of Professor N. E. Nörlund. The groundwork for the map was carried out by four teams, each consisting of a surveyor and two Greenlandic assistants. The surveyors expressed their admiration for Holm and Garde's map, which, according to the standards of that time, was an extremely fine piece of cartographic work. I feel I must express the same admiration for the work of my surveyors who in the short time at their disposal completed more than 3000 intersections. Much new land was surveyed, many new fiords were recorded, and over long stretches the map has been greatly altered, especially in the vicinity and to the north of Skjoldungen, where Captain Graah's original map was lost in 1830, and where Holm and Garde did not make supplementary triangulation in 1885.

The geological surveys were led by R. Bøgvad, who carried out investigations and made collections at over 500 places in the sphere of our operations. This southeastern coast is granite and gneiss, and there are none of the interesting sedimentaries that we find farther north. Furthermore, all search for extensive mineral deposits has

given a negative result. The geologist also made zoölogical and botanical collections in more than 100 localities.

Dr. Poul Nörlund, who was in charge of archeological excavations in the fiords of Julianehaab, did the expedition the honor of taking part in an excursion to the Tingmiarmiut area. On that trip he succeeded in finding two more Norse farms in the Cape Farewell district—the most southerly of all known Norse farms in what was then the East Settlement. On the East Coast itself Dr. Nörlund's investigations gave negative results; the so-called Rolf ruin in Lindenow Fiord is still the only definitely known Norse ruin on the East Coast.

In contrast with the Norse archeological research work, the Eskimo archeological work was extremely rich in its results, for this is a coast on which in former days there was a large Eskimo population. Altogether, about 200 house ruins were surveyed; all the more important were visited by Dr. Mathiassen and he excavated 21 ruins. He divides the ruins into three groups, the oldest of which date back to the fourteenth century.

As time and opportunity permitted, I myself took part in the archeological work of examination and survey, but this time my interest was concentrated on the possibilities of settlement on the southeastern coast. In sum, it may be stated that there is excellent sealing all along the coast, but no land game. Nor are there fish in the fiords or along the coast with the exception of trout in some of the rivers. Poul Hansen's fishery investigations in the waters about Lindenow Fiord, it may be noted, showed that the sea was too deep and, on the whole, too cold to support cod, though there were numbers of sharks. Thus there is no basis for a white population: a Greenlandic one could doubtless find support. But as the game is exclusively seal and as this animal is migratory, life there will always bear the stamp of uncertainty even for these frugal natives.

Before a definite pronouncement can be made on the habitability of this coast further investigation into hunting conditions is desirable, and two of the members of the expedition were left behind at the old Danish-Greenland hunting station at Narssaq, Lindenow Fiord, for this purpose.

THE CIRCUMNAVIGATION OF FRANZ JOSEF LAND

N. N. Zubov

Oceanographical Institute of the U. S. S. R.

In connection with the Second International Polar Year various scientific institutions of the U. S. S. R. planned an extensive program of meteorological and oceanographical investigations. While it is too early yet to speak of the scientific results in any detail, the reports of success already received promise a picture of the Polar Seas such as we have never had before. Among outstanding achievements are the accomplishment for the first time in a single season of the Northeast Passage, by the "Sibiriakov" expedition under Professor Otto Schmidt, and the first circumnavigation of Franz Josef Land, by the "Knipovich," under Professor N. N. Zubov. The success of the little "Knipovich" is a proof of the good work that can be accomplished in high latitudes by small boats if personnel and crew are experienced and if physical conditions can be predicted. Professor Zubov had forecast favorable ice conditions for his expedition, and these were realized. In the following article he describes the course of the expedition and the hypothesis upon which it was founded—that the temperatures of the North Cape Current can be used to foretell the state of the ice in Barents Sea.

ON August 18, 1932, the *Knipovich* left Murmansk for her season's work in the Arctic. This included the making of hydrological sections across the North Cape Current along the Kola meridian (33° 30′ E.) and across the straits between Spitsbergen and Franz Josef Land and between Franz Josef Land and Novaya Zemlya (see Fig. 1).

The *Knipovich* is a wooden vessel built in Norway in 1928, of 100 tons displacement and with a 125 horse-power motor. She handles splendidly in a heavy sea and is admirably adapted for ice navigation: with a fore draft of six feet and stern draft of ten feet she literally turns on the heel. The scientific personnel of the *Knipovich* numbered six, including a woman geologist, Dr. M. W. Klenova; the crew ten. We had fuel for twenty days in the tanks and for ten days in barrels. We carried no special winter equipment and could by no manner of means be described as a "polar expedition." It was not our intention to run any risk of wintering in the Arctic. I had complete faith in the ship—and I am a master mariner as well as an oceanographer—and in my forecast of favorable ice conditions in the high latitudes of our proposed itinerary.

We carried out the usual oceanographical investigations along the Kola meridian as we proceeded northward. The wind, unfavorable from the start, had increased to a gale (22 meters/second) by the time we reached the 75th parallel, and we were compelled to stop work till we reached 79° N. Here we saw that notwithstanding the strong northwest winds that had blown continuously all the sea westward

of a line from White Island (Giles Land) to the King Karl Islands was blocked by heavy ice.

We reached the southeast end of White Island on August 28 and turning east made Victoria Island the next day. Though the weather had cleared it was not easy to find the island because on existing maps its position and size are not correct.[1] We charted the island and raised the U. S. S. R. flag on the northeast end, the only place where landing is possible, all the rest being steep ice slopes. On the shore some geological specimens were collected.

The Franz Josef Archipelago

On August 30 we reached Cape Mary Harmsworth, the southwestern end of Alexandra Island, and set our course northward, intending to repeat the *Knipovich's* work of the previous year along the forty-second meridian. Weather and visibility were fairly good, and there was no ice but a few scattered icebergs. The next day in 82° 05′ N. and 42° E. we met with light ice. Not to be impeded in our observations, we turned first to the east, then southeasterly under a storm from the north. September 1 found us at anchor in Teplitz Bay. We spent two hours here and got news of ice conditions in the British Channel from the staff of the hydrometeorological station that was being erected for the Polar Year.

At midnight we doubled Cape Fligely, the northern point of Franz Josef Land. The weather became splendid, and we hoped the strong northwest wind, which had blown for a fortnight, would have cleared a passage along the eastern shores of Franz Josef Land.

At 5 a. m. we made Hvitenland (White Islands), discovered by Nansen on the *Fram* expedition, and found that Eva and Liv, named by Nansen after his wife and daughter, are, in fact, joined together by a low stretch of ice-covered land[2] and are situated not so far to the east as represented on the charts.

Making our way around Evaliv—as we named this double island—we were obliged to enter the ice. At first broken and melting, the ice increased in thickness and area as we zigzagged our way to Graham Bell, which was reached in the afternoon of September 2. It was a risk to enter the ice, especially from the north, without the slightest information as to conditions southward. Off Cape Kohlsaat we encountered a field of real pack and, unable to find a passage between this field and the shore, had to sail eastward for twenty to twenty-five miles.

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[1] Worsley reported Victoria Island as placed too far east on the chart. See F. A. Worsley: Under Sail in the Frozen North, London, 1927, p. 292.—Edit. Note.

[2] Compare Lincoln Ellsworth and Edward H. Smith: Report of the Preliminary Results of the Aeroarctic Expedition with *Graf Zeppelin*, 1931, *Geogr. Rev.*, Vol. 22, 1932, pp. 61–82. "We passed over two very curious overlapping disks of ice, smoothly polished and one to three miles in diameter. This was Eva Island, low, double-mushroom-shaped, completely glaciated" (p. 67).—Edit. Note.

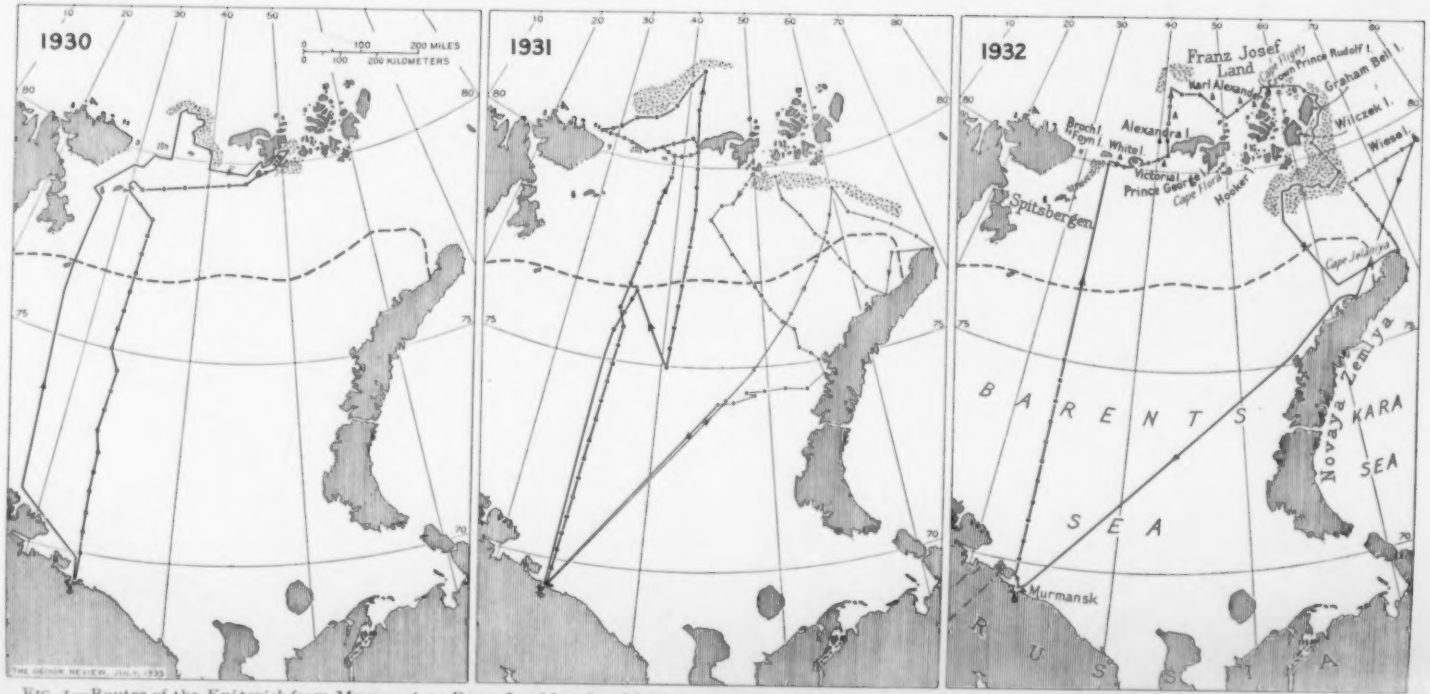

FIG. 1—Routes of the *Knipovich* from Murmansk to Franz Josef Land and back in 1930, 1931, and 1932. The route of the *Perseus* in 1931 is shown by a lighter line. Drift ice encountered is shown; solid triangles on the map for 1932 indicate icebergs; dots indicate full oceanographical stations; the broken line indicates the average limit of ice in August according to "The State of the Ice in the Arctic Seas," Danish Meteorological Institute. Scale of maps 1 : 20,000,000.

On Route to Novaya Zemlya

It was 6 o'clock in the morning of September 3 before we breathed freely. The weather, become misty in the night, cleared up. We sighted Graham Bell and Wilczek islands, the ice became looser, we resumed our observations, and set our course for Cape Jelaniya, the northern end of Novaya Zemlya. Again the weather became foggy with a strong east-northeast wind that put the ice in motion and closed all the passages to the south. Lacking a way out we turned westward—though as it turned out my original idea of going east would have been justified. The only excuse is that we were tired: it is not a simple thing to double Franz Josef Land!

In the morning of the 5th we had a narrow escape from being trapped in the ice. At noon the wind changed to the northwest, grew in force, and opened passages to the southwest. We advanced southward for about thirty miles and then deliberately entered a heavy ice field to transfer motor oil from the barrels to the tanks. Having finished that operation in the afternoon of the 6th, we left the ice and with a storm from the northwest proceeded on our way. On September 9 we came to Cape Jelaniya and turned northward to complete our work in the strait between Franz Josef Land and Novaya Zemlya, which we had been prevented from completing by ice. After having done so we turned to Wiese Island, which we reached on the 12th without seeing a vestige of ice. The way before us was open in all directions—an opportunity that perhaps will not soon be repeated—but our supplies were at an end, and we turned homeward. By September 21 we were at the Murman station of the Oceanographical Institute (at Selo Polarnoye, near Murmansk), all in good health and the ship in good condition but with fuel for only two hours left.

During her voyage the *Knipovich* covered more than 3000 nautical miles, made more than 400 wire soundings, occupied 38 full oceanographical stations at which temperature, salinity, oxygen, hydrogen-ion concentration, phosphoric acid, and nitrates were determined at different depths from the surface down to the bottom. At 75 places bottom samples also were collected and samples of plankton and bentos were taken. Throughout the voyage meteorological observations were carried out according to the program of the Second International Polar Year.

The expedition proved the soundness of the underlying ideas on which it was based. These I shall now outline.

Temperatures in Barents Sea

As early as 1909 Nansen and Helland-Hansen in "The Norwegian Sea" had pointed out a correlation between the temperature of the North Cape Current off the Murman coast and the state of ice in

of ice in August according to "The State of the Ice in the Arctic Seas," Danish Meteorological Institute. Scale of maps 1 : 20,000,000.

TABLE I—MEAN TEMPERATURES OF THE NORTH CAPE CURRENT ALONG THE KOLA MERIDIAN (33° 30′ E.), LATITUDE 69° 30′ TO 72° 30′ N.: DEPTH 0-200 METERS

YEAR	J	F	M	A	M	J	J	A	S	O	N	D
1900	....	....	....	....	1.97	....	2.97	....	3.95	3.85	....	3.78
1901	....	....	2.35	2.10	2.18	2.61	3.07	....	....	....	....	....
1902	....	....	....	....	....	2.23	....	....	....	....	....	....
1903	....	2.27	2.27	....	1.96	....	....	4.10	....	....	3.89	....
1904	....	3.05	....	2.34	2.60	....	....	4.65	....	....	....	....
1906	....	2.85	....	....	2.47	....	....	3.94	....	....	....	....
1921	....	....	....	....	3.91	....	....	5.45	....	....	....	....
1922	....	....	....	....	2.52	....	....	5.06	....	....	5.03	....
1923	....	....	3.13	....	....	....	....	....	....	....	4.00	....
1924	....	....	....	....	2.50	....	....	....	....	....	....	4.54
1925	....	....	....	....	....	2.97	....	4.75	....	....	....	....
1926	....	....	....	....	....	....	....	3.84	....	....	....	4.13
1927	....	....	....	....	2.67	....	....	4.13	....	....	....	....
1928	....	....	2.56	....	....	3.02	....	....	4.92	....	....	4.16
1929	....	....	2.56	....	2.07	....	....	....	4.82	....	....	4.66
1930	....	3.87	3.35	....	....	3.60	4.17	4.91	5.10	....	5.31	....
1931	4.56	3.44	2.97	2.87	3.06	....	3.87	4.55	....	5.12	....	....
1932	3.66	....	....	....	2.55	....	3.81	4.59	....	....	....	....

Barents Sea in the same year. However, at that time observations were so few that it was not possible to come to more detailed conclusions.

In 1928 I had at my disposal about 40 hydrological sections along the "Kola meridian" (33° 30′ E.) made in different seasons of the year. From these I calculated the mean temperatures from the surface down to 200 meters from 69° 30′ N. to 72° 30′ N. The result is given in Table I.

I then calculated the change of mean temperatures for a day (gradient) in the summer and found that, though different sections were not made on the same days of the months and though the mean temperatures differed greatly from each other, the time gradient of temperature remained nearly constant, namely about two hundredths of a degree a day.[3] This remarkable fact permits reduction of the mean temperature on any given day to any date desired. Thus from temperatures measured in May the temperatures of August can be predicted. The temperatures of the sections along the Kola meridian are so reduced in Table II.

CORRELATION BETWEEN TEMPERATURES AND ICE COVER

From the charts issued yearly by the Danish Meteorological Institute, "The State of Ice in the Polar Seas," the percentage of the ice cover in Barents Sea for the five summer months April to

[3] N. N. Zubov: Hydrological Investigations in the South-western Part of Barents Sea During the Summer 1928. *Trans. Oceanogr. Inst.*, Vol. 2, No. 4, Moscow, 1932, pp. 40–41. (In Russian with English summary.)

TABLE II—MEAN TEMPERATURES OF THE NORTH CAPE CURRENT REDUCED TO JUNE 1 AND AUGUST 1

(In degrees centigrade)

YEAR	JUNE 1	AUG. 1	YEAR	JUNE 1	AUG. 1	YEAR	JUNE 1	AUG. 1
1900	2.12	3.13	1921	3.95	5.19	1928	2.97	4.11
1901	2.22	3.52	1922	3.00	4.48	1929	2.52	3.88
1902	1.91	3.21	1924	2.58	3.88	1930	3.58	4.82
1903	2.53	3.88	1925	2.85	4.32	1931	3.35	4.33
1904	3.06	4.32	1926	2.04	3.34	1932	2.97	4.15
1906	2.92	3.91	1927	2.73	4.01			
						MEAN	2.80	4.02

August was measured for the corresponding years. The results are given in Table III. If we now correlate the mean reduced temperatures for June with the mean extent of summer ice we get $y = 12x$, where y represents the divergence of the area of the ice cover from the mean expressed in percentages and x represents the divergence of the temperature reduced to June 1 from the mean of the years of observation expressed in degrees.

The coefficient of correlation will be $r = 0.713$, the probable error $E = 0.081$, and the ratio $\frac{r}{E} = 8.8$, a very satisfactory figure, because, as is known, correlation gives good results if $\frac{r}{E}$ is greater than six. Thus a correlation between the temperature of the North Cape Current and the state of the ice in Barents Sea was established.

In 1928 an important piece of work was carried out: the direction and the velocity of the North Cape Current in various parts of Barents Sea were measured by direct (current meter) and indirect methods (dynamic and thermal calculations).[4] The result showed that it

[4] *Ibid.*, pp. 16–39.

TABLE III—ICE-COVERED AREA IN BARENTS SEA AND NUMBER OF ICEBERGS SOUTH OF THE FORTY-EIGHTH PARALLEL

(Ice area in percentages for the five summer months)

YEAR	ICE AREA	ICEBERGS	YEAR	ICE AREA	ICEBERGS	YEAR	ICE AREA	ICEBERGS
1900	51	89	1911	55	396	1922	36	523
1901	53	88	1912	65	1019	1923	38	236
1902	65	41	1913	60	550	1924	37	11
1903	59	802	1914	55	731	1925	38	109
1904	40	265	1915	54	468	1926	53	345
1905	42	845	1916	63	54	1927	57	389
1906	46	405	1917	74	38	1928	45	515
1907	40	638	1918	60	199	1929	60	1351
1908	39	222	1919	51	317	1930	40	475
1909	58	1024	1920	42	445	1931	39	13
1910	53	50	1921	43	746			

would take more than a year's time for water to pass from the Murman coast to the northern end of Novaya Zemlya.

Conditions in Barents Sea, 1930 to 1932

In December, 1929, an increase in the temperatures of the North Cape Current off the Murman coast was noticed; and I asked permission of the Oceanographical Institute to go on the *Knipovich* for investigations in the high latitudes of Barents Sea, since work under favorable ice conditions is more economical and gives better results. Permission obtained, I started from Murmansk on September 4, 1930. The first ice encountered was in 81° 20′ N. (see Fig. 1). But the ice would not permit us to approach Franz Josef Land from the north or the west. The southern sounds of the archipelago were entered on September 14; ten days later we returned home.

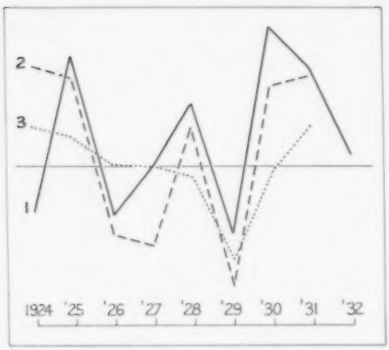

Fig. 2—Graph illustrating the correspondence in divergencies from the mean of: 1, temperature of the North Cape Current; 2, area of ice in summer in Barents Sea; number of icebergs south of the 48th meridian.

In 1931 the temperature of the North Cape Current was a little lower, but still very high. The wave of warm water had proceeded eastward, and the *Knipovich* and the *Perseus*, also sent out by the Oceanographical Institute, were able to accomplish fine work in the northern part of Barents Sea (Fig. 1). The former reached 82° 05′ N. and 42° E. before meeting ice and then followed along the edge of ice to Broch and Foyn islands. The latter carried out work between Franz Josef Land and Novaya Zemlya. At the same time the Soviet sealing ships *Red Murmanetz* and *Lensovet* made an extensive penetration of the sounds of Franz Josef Land. The state of the ice north of Spitsbergen also was very favorable as was proved by the Swedish-Norwegian Arctic Expedition in the *Quest*. Northeast Land was circumnavigated, and the islands between Northeast Land and Franz Josef Land were visited and also Alexandra Island.[5]

In 1932 the temperature of the North Cape Current was lower than in 1930 and 1931, almost at its mean value, and the state of the ice in the spring and up to the middle of summer was not favorable. The ice breaker *Malygin* on her way to Franz Josef Land met with very heavy ice on July 17 in 78° 30′ N., and the trawler *Dvina* on July 29 in 75° 40′ N. and 25° E. Bad ice conditions were also reported

[5] H. W. Ahlmann: L'expédition arctique suédo-norvégienne (Terre du Nord-Est et mers voisines). *Ann. de Géogr.*, Vol. 41, 1932, pp. 177–187.

in the beginning of July from the Kara Sea. However, my confidence that the cold wave would not yet have reached the regions we were to investigate was justified by the event.

Temperature Waves and Ice Prediction

When I returned to Moscow I received new evidences of the importance of these warm or cold waves that emanate from the Gulf of Mexico and the Atlantic. As is known, not all the waters of the Atlantic Current enter the Polar Basin. A branch turns to the left before Iceland and the entrance to the Polar Basin between Spitsbergen and Greenland are reached, and this stream "attacks" the ice driven southward by the East Greenland and Labrador currents. Clearly the warmer the "attacking" waters are, the less ice and the fewer icebergs reach southern latitudes.

Figure 2, representing the mean temperatures of the North Cape Current, the mean ice cover in Barents Sea, and the number of icebergs reported south of the forty-eighth parallel,[6] shows a remarkable correspondence between the three curves.

I learned that the temperature of the Gulf Stream off Florida in 1928 was five degrees higher than usual,[7] and I suppose that the same was the case with the main body of water that forms the Atlantic Current. The crest of this warm wave reached the Murman coast in 1930, as I have already described; and I might say that it was on the crest of this warm wave of 1928 that we doubled Franz Josef Land.

I do not know much about thermal conditions in the southern latitudes of the North Atlantic in the following years. But in 1929 the number of icebergs south of the forty-eighth parallel established a maximum for thirty years of observations. This is evidence that a large mass of cold water in 1929 attacked the Atlantic Current, intermixed with it, and thus probably formed the cold wave of 1929. It reached the Norwegian Sea in 1931, and that is why in 1931 the sea temperature south of Iceland was 3° and at Lofoten 5° below normal.[8] Now this cold wave is approaching the Polar Seas. In 1932 the mean temperatures of the North Cape Current began to get lower. We on the *Knipovich* met with ice east of Spitsbergen, and the *Perseus* could not circumnavigate Spitsbergen. The cold wave will undoubtedly be the cause of bad ice conditions in Barents and Kara seas the coming season. On the other hand the propagation of the warm wave of 1928 farther to the east will create favorable ice conditions east of Northern Land.

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[6] International Ice Observation and Ice Patrol Service in the North Atlantic Ocean, Season of 1931. *U. S. Coast Guard Bull. No. 21*, Washington, 1932, p. 25.

[7] J. W. Sandström: Der Golfstrom und das Wetter, *Gerlands Beiträge zur Geophysik*, Vol. 32, 1931, pp. 254–259.

[8] *Trans. Amer. Geophys. Union*, Thirteenth Ann. Meeting, April 28–29, 1932, Natl. Research Council, Washington, 1932, p. 257.

A PHYSIOGRAPHICAL MAP OF TANGANYIKA TERRITORY

E. O. Teale and E. Harvey

Geological Survey of Tanganyika Territory

[With separate map, Pl. IV, facing p. 412]

The Construction of the Map, by E. Harvey

TO the interesting and instructive article "The Physiographic Method of Representing Scenery on Maps," by Erwin J. Raisz, in the *Geographical Review* of April, 1931, we are indebted for the inspiration of the physiographical map of Tanganyika Territory.

The initial difficulty faced in the preparation of such a map was the absence of a reliable topographical framework. All available material was pressed into service. Detail, for the most part, was taken from the War Office map in 1:2,000,000, although the contour intervals on it are too great to emphasize many important features. The lack of a topographical base indeed provided an additional incentive to the drawing of the physiographical map, since this method lends itself much more readily to the incorporation, with reasonable faithfulness, of details from photographs and panoramic sketches than do the more precise methods of contouring, shading, etc. To the large number of photographs, sketches, and in some cases verbal descriptions supplied by the officers of the Geological Department we are indebted for the majority of the features shown that do not appear on other maps of the Territory. It must be realized that this map is far from complete; in fact, large areas are little more than conjectural because of our still imperfect knowledge of the terrain.

Every endeavor has been made to adhere closely to Mr. Raisz's table of physiographical symbols. Wherever it was found necessary to introduce new symbols—for example, that used to depict fault scarps—it has been borne in mind that "the good symbol is that which can be read without explanation."

Notes on the Physiography, by E. O. Teale

Tanganyika Territory, an area of some 360,000 square miles lying athwart an important section of the great zone of East African rift dislocations, affords a striking example of geographical contrasts—plateaus and troughs, sheer scarps and wide alluvial plains—the diversity of land forms therein encompassed proving the delight

alike of traveler and geomorphologist. The snow-capped dome of Kibo, which, with the smaller jagged peak of Mawenzi, constitutes the volcanic mass of Kilimanjaro, is more than 19,000 feet above sea level and is the highest point of the African continent. Below the permanent ice cap and the lava screes of this great mountain, at an elevation of about 10,000 feet, there is an alpine zone wherein grow tree lobelias, giant heather, and groundsel, as well as other unfamiliar plants. The two most noteworthy lakes in Africa border the Territory; on the west is Lake Tanganyika, the world's second deepest lake, a biological enigma with a unique fauna which has developed along independent lines. By contrast, Lake Victoria on the north, the largest fresh-water lake in the Old World, is comparatively shallow. Both these lakes are kept fresh by outflow drainage—to the Atlantic Ocean via the Lualaba and Congo rivers in the one case, to the Mediterranean Sea via the Nile in the other. Many of the numerous lakes situated along the rift zone have no discharge and under the influence of a semiarid climate are becoming progressively more saline, in some cases having reached the stage of salt-crust formation. Of the latter, Lake Natron on the Kenya border is perhaps the best known.

Almost every type of climate is represented in Tanganyika, the range being illustrated by the glaciers and ice-lined crater of Kibo and by the tropical humidity of the Indian Ocean seaboard. The highlands of the volcanic areas are well watered and fertile, and their rich soil produces some of the world's finest coffee, as well as wheat and maize. In the more elevated regions occur extensive patches of rain forest, in sharp contrast to the parched savana and thorn-bush semidesert of the arid plains below. The Territory abounds with game animals of all description, which roam in vast herds over the grassy plains and in these more enlightened days are more likely to be "shot" with cinematograph camera than with rifle.

The map shows at a glance the principal outlines of this fascinating region and also makes clear certain economic considerations consequent on them.

Some Economic Consequences of the Relief

Communications by road or rail are materially influenced by the disposition of the scarps and highlands. Whereas in South Africa the entrance from the coast to the inland plateau usually means the climb of one escarpment, some routes here form a veritable switchback with consequent "loss of level."[1] Air communications are less affected, but even so the influence of topography on air currents is by no means negligible. The complex reaction of climate on the

[1] C. Gillman: Report on the Preliminary Surveys for a Railway Line to Open up the South-West of Tanganyika Territory, 1929, London, 1929.

topography affects the location, construction, and maintenance of roads and railways. The effect of the 1930 floods on communications and railways, for instance, is referred to in the Annual Report of the Geological Survey for 1931.

The influence of the elevated volcanic masses on the local climate

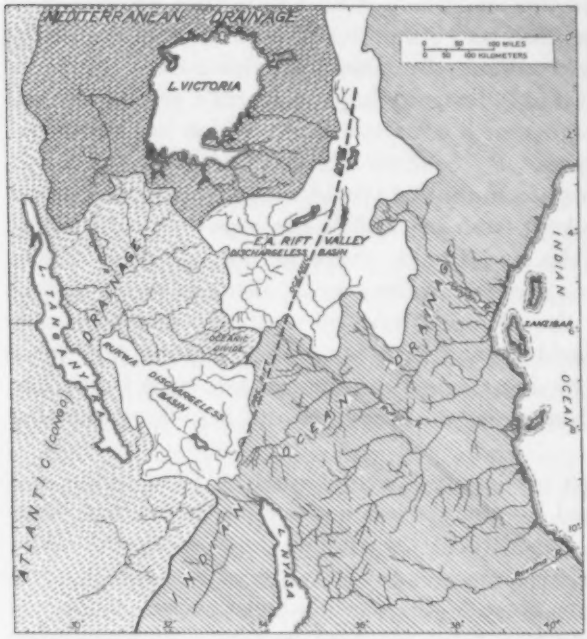

FIG. 1.—Map showing the area and distribution of oceanic drainages and dischargeless basins with existing watersheds and the probable position of a main pre-rift oceanic divide.

The lakes and dischargeless basins show clearly the great extent to which a normal and adjusted drainage has been disturbed by tectonic movements.

is marked. In certain zones they support evergreen forest and form the source of many permanent streams, which, particularly in the case of Kilimanjaro and Meru, are of great importance for both native and European settlement. The contrast afforded by these refreshing and productive areas with the parched, sparsely occupied surrounding country is striking.

The great lakes, Nyasa, Tanganyika, and Victoria, with their adjoining highlands, form important local meteorological foci where the influence on rainfall and humidity is noticeable. Some parts of the Territory have an abundance of permanent flowing streams and a vast supply of unused water power. Still larger areas are practically riverless, with an ill defined system of wide claypans, swampy for a few months and hard-baked and cracked for the remainder of the year. Nearly a quarter of Tanganyika is dischargeless—an area of the Eastern Rift covering 78,500 square miles and the Rukwa Basin of some 6000 square miles. The subarid regions react on the quality of the ground water and induce increased salinity, and this character is further greatly influenced within the areas of the large dischargeless basins. The reaction of the climate on the type and distribution of vegetation has largely determined the habitat of the tsetse fly—savana bush country. One far-reaching result has been to concentrate human occupation into the more restricted fly-free areas where cattle

can be kept. Serious overstocking and overgrazing, with disastrous and increasing soil deterioration and erosion, have followed. This condition in turn reacts adversely on both surface and ground-water supplies.

In relation to the mineral resources of the Territory attention may be called to the effects of changes in the drainage—due mainly to tectonic disturbances—of far-reaching and often complex character. Their history is obscure for the most part; but the tracing of the source of now isolated deposits of gold, diamonds, or tin is closely dependent on elucidation of past physical conditions. The case of the Lupa gold field is interesting. Intense local rejuvenation caused by the Rukwa rifting has here laid bare old high-level, pre-rift alluvial concentrations and reconcentrated some of the gold in young valley channels, exposing also innumerable quartz reefs that have contributed to the alluvial occurrences.

From these illustrations of their economic significance we turn to a short commentary on the chief features themselves. It is not intended to discuss here the various theories that have been advanced to explain the mechanism by which the great rift dislocations took place.[2] As a first step towards the solution of this problem we need a comprehensive grasp of the nature of the surface features and their relationship to one another.

The Scarps

The most striking feature of the map is the series of scarps that cross the Territory trending mainly north-northwest to northwest or north-northeast to northeast. At a distance from the coast varying from a few miles up to about twenty is a roughly north-northeast scarp line. The crest rises from 1000 to 1500 feet above sea level, and, owing to the nature of the rocks, relatively soft late Mesozoic to Tertiary marine sediments, it is much fretted by erosion. The line is breached by wide gaps at the crossings of such rivers as the Ruvu, the Rufiji, and the Lukuledi.

The Pugu scarp, west of Dar es Salaam, is typical and most accessible, as it is crossed by the Central Railway. Here it forms an east-facing scarp of a block slightly tilted to the west. South of Lindi, the seaward-dipping Tertiary sediments flanking the Makonde Plateau diminish the scarp-forming effects of the uplifted block.

[2] See especially Carl Uhlig: Der sogennante Grosse Ostafrikanische Graben zwischen Magad (Natron-See) und Laua ya Mueri (Manyara-See), *Geogr. Zeitschr.*, Vol. 13, 1907, pp. 478–505; Fritz Jaeger: Vorläufiger Bericht über eine Forschungsreise in das abflusslose Gebiet Deutsch-Ost-Afrikas, *Zeitschr. Gesell. für Erdkunde zu Berlin*, 1908, pp. 250–265; Erich Obst: Das abflusslose Rumpfschollenland im nordöstlichen Deutsch-Ostafrika, *Mitt. Geogr. Gesell. in Hamburg*, Vol. 29, 1915, pp. 7–268 and Vol. 35, 1923, pp. 1–330; Erich Krenkel: Geologie Afrikas, Part I, Berlin, 1925; J. W. Gregory: The Rift Valleys and Geology of East Africa, London, 1921. Supplementary information has been steadily collected by the Geological Survey and also by Mr. C. Gillman, whose reconnaissances and detailed railway surveys have enabled him to study many little-known areas.

The next scarp line, also with a general north-northeast direction, starts at the west of Tanga and follows in general the boundary between the coastal sediments and the old crystalline complex. It has been termed by Gillman the "fall line" since most of the streams that cross it, including even such actively eroding streams as the Pangani and the Rufiji, are interrupted by waterfalls and rapids. This

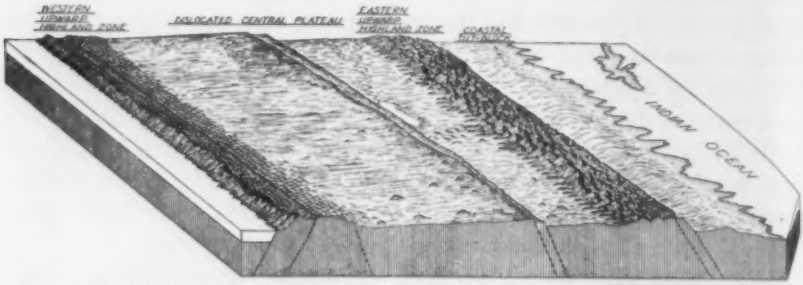

FIG. 2—Simplified and generalized block diagram of structure across the center of Tanganyika Territory from east to west.

old fault line, along which renewed movement has taken place to some extent, represents one of the marginal fracture lines of the continent.

THE USAMBARA AND PARE BLOCKS

To the west of the "fall line," attention may be directed to scarps of the Usambara and Pare blocks in the northeastern part of the Territory. The main trend of their dominant scarps is northwest, but north-northeast scarps, also well developed, cut the highlands into separate blocks with two well defined gaps of riftlike character. That these features are definite fault scarps has not been accepted by all observers, but to the writer the morphological evidence is strongly in favor of such an explanation.

THE KILOMBERO-TURIANI LINE

The next important scarp, omitting the outlying Mahenge block and the lofty massif of Uluguru, is that of the Kilombero-Kilosa-Turiani line, a feature of major magnitude and of great importance in various ways in the country. It is intersected by the Ruaha in a practically impassable gorge and at Kilosa by the Kinyasungwe, an antecedent valley which is made use of by the railway as a means of entrance to the Central Plateau region. The story of this valley alone would form a study of far-reaching interest in relation to many geomorphological problems in the Territory.[3]

The general direction of this tectonic line is north-northeast to

[3] Some of these have already been touched upon by C. Gillman. See *Ann. Rept. Geol. Survey Tanganyika Territory, 1930*, Dar es Salaam, 1931, pp. 14–15.

northeast, but it is set back in the vicinity of the Kilombero by an important west-to-west-northwest line. In the vicinity of Kilosa and northward the scarp is much eroded, and a higher and still more eroded parallel scarp is set back into the highlands. To the south, in the vicinity of the Kilombero Valley, it would appear that renewed movement has given both increased height and freshness to its character. Throughout its length the line intersects rocks of the ancient crystalline complex, but in the vicinity of Ruhembe a block of Karroo sediments flanks it on the east. To the north the scarp line gradually fades out.

The Volcanic Mountains

Passing now westerly through the Iringa-Usagara-Kaguru plateau blocks—much dissected and with many tectonic details yet to be worked out—one emerges into the important Central Plateau region, traversed by a complex system of scarps which is the direct extension of the Eastern or Great Rift Zone of Kenya. This region of tectonic disturbance has also been one of marked volcanic activity. Of some five important volcanic foci in East Africa, two lie in Tanganyika Territory. The northern area includes Kilimanjaro and a host of other volcanic piles of different ages and stages of preservation. In this area also is the region of the giant craters with a number of points rising more than 10,000 feet and providing a fascinating subject for vulcanological study. The other and smaller focus centers around Rungwe Mountain at the northern end of Lake Nyasa at the intersection of two important fracture systems of the rift dislocation.

Scarps of the Central Plateau: The Eastern Zone

The general plan of the scarp system of the Great Rift Zone is well shown on the map, but in the true sense of the word the features are not those of typical rifts: they are more correctly described as step or "trapdoor" faults (*Bruchstufe* of the German writers). Lines of swamps, lakes, or deep alluvial plains usually lie along the base of the scarp, and there is as a rule only one wall instead of two as in a true rift. This important zone may be taken to extend from Mbeya Mountain in the southwestern part of the Territory northeasterly to the Kenya border, well to the west of Kilimanjaro, a distance of more than 400 miles. Because of the composite and curving nature of the fractures, it affects a strip of country from 50 to 100 miles wide.

Starting near Mbeya, an important focus to be discussed later, a short, more or less east-west scarp abruptly severs the highlands of Buanji and the Livingstone Mountains, at the base of which is a wide swampy plain of alluvium over late Tertiary or Pleistocene lake beds. The scarp is not joined tectonically with the Mbeya scarp; a pile of volcanic material blocks up what apparently was a

trough at one time between these. The Mbeya scarp extends northeasterly as a little-eroded straight-line feature about 1500 feet in height, gradually getting lower till at a distance of 240 miles it is about 500 feet high and known as the Fufu scarp. Here it ends against the western ranges of the Usagara block. Several valleys cut into it, notably the Kizigo River, a tributary of the Ruaha. The highlands of the western Usagara and Iringa blocks tilt slightly west or west-northwest towards the scarp, plunging their somewhat eroded front into the wide alluvial plains of the Great Ruaha River, which occupies the depression adjacent to this great scarp line. A series of tectonic features and less perfect scarps border the western margin of the highlands, giving the Ruaha depression something of the character of a normal rift; but the eastern side has not the sharp, fresh, wall-like feature of the western side.

From the northeastern end of the Mbeya-Fufu scarp it is necessary to take a big jump northward to the commencement of the next great feature, which may be termed the Kilimatinde-Turu-Mbulu-Natron zone. The first scarp of this system is encountered on the Central Railway some 50 miles west-northwest of Dodoma. Here it bounds the western and southwestern margin of the Bubu dischargeless basin. The trend is at first northwest, then north-northeast, turning to northeast to join up with the scarps of the easterly projecting Kondoa block.

Returning to the railway line, an ascent is made onto a narrow westerly-tilted block, which also is overlooked by the Kilimatinde-Manyoni section of an important continuous scarp extending 280 miles to the Kenya frontier and varying in direction from north to northeast with an east-west kink near the extinct volcano of Hanang.

Both from morphological and geological evidence this fault, as is the case with all the others of the central system, is extremely youthful and is dated at late Pleistocene at the oldest. It cuts across the old crystalline rocks and the late Tertiary lavas and dislocates young deposits of superficial crusts and late volcanic ejectamenta. A noteworthy and characteristic feature is the chain of alluvium-filled plains, swamps, or lakes lying along the foot of the scarp. Branching from this scarp on the Kenya frontier is another major scarp of similar age and character. It trends south-southwest with a somewhat zigzag course till near the head of Lake Eyasi, where it turns southwest as an imposing wall along the western side of that great depression. Between Eyasi and Natron is the now famous Oldoway section where definite paleontological proof has been obtained by Leakey, Reck, and Hopwood[4] of its youthful character. Minor tectonic lines lie between this scarp and that previously described, including a small definite trough known as the Hohenlohe Rift.

[4] *Nature*, No. 3260, Vol. 129, 1932, April 23, p. 607.

The scarps of the Iramba Plateau to the south of Eyasi are well brought out. On this plateau are relics of what are probably young lake beds, whose exact age it has not yet been possible to determine. Thence westerly there is a wide extent of country free from scarps. The scarp line from the southwestern corner of Lake Victoria southwesterly toward Lake Tanganyika follows closely for most of its length a definite fault line, but this feature is probably more correctly described as a fault erosion scarp.

The Western Zone

The western highlands, which include chiefly the regions of Mbozi, Ufipa, Ukavende, and Uha, rise more than 5000 feet in general level with older topography upon them rising often to well over 6000 feet. They are interrupted by transverse gaps, partly erosional, partly tectonic. Their eastern and western margins are, generally speaking, definitely tectonic dislocations. The main blocks appear to show little or no tilting; but minor fault blocks adjoining them are sometimes distinctly tilted, and along the margin of Lake Tanganyika there are several narrow downfaulted blocks that definitely tilt eastward away from the lake.

The western part of the rest of the Territory provides, however, a most important zone of undoubted tectonic features. It forms part of that most striking feature of eastern high Africa with its curving chain of elongated deep lake troughs. In the section here considered the great troughs of Tanganyika and Rukwa call for attention, as does also a part of Lake Nyasa, which has been well described by Dixey.[5] The Rukwa scarps are steep, straight, and fresh; the western one about 3000 to 4000 feet, the eastern one about 600 feet above the alluvium of the floor. The special and interesting features of the eastern Rukwa scarp have been brought out by mapping by Grantham. Its remarkable freshness and sharpness is ascribed to the fact that until recently it was preserved under the water of the lake.[6] The actual face visible is that of a normal fault. Recent desiccation of the area has lowered the level of the water 600 feet, laying bare a scarp over which the streams drop in falls that have as yet made but slight impression in the hard rock. The throw of the fault, judged from the dropped topography buried beneath the lake sediments, must be at least 1200 feet and is probably much more. Many structural features of shear and thrust in the southern vicinity of the scarp towards the Mbeya Range are shown by detailed mapping to be very ancient and long antecedent to the rift movements.

[5] Frank Dixey: Recent Investigations into the Geology of Nyasaland, extr. from *Compte Rendu, 14th Session, Internatl. Geol. Congr. 1926*, Madrid, 1928; see also the same: Recent Geological Discoveries in Nyasaland, Central Africa, *Pan-American Geologist*, Vol. 48, 1927, pp. 25–36.

[6] D. R. Grantham: Lupa Goldfield, *Tanganyika Geol. Survey Bull. No. 3*, Dar es Salaam, 1932.

The character of the topography surrounding Lake Tanganyika merits a more detailed consideration than can be given here, and as yet no sufficiently accurate and complete map is available for a full analysis. Though high and steep slopes commonly border the lake,

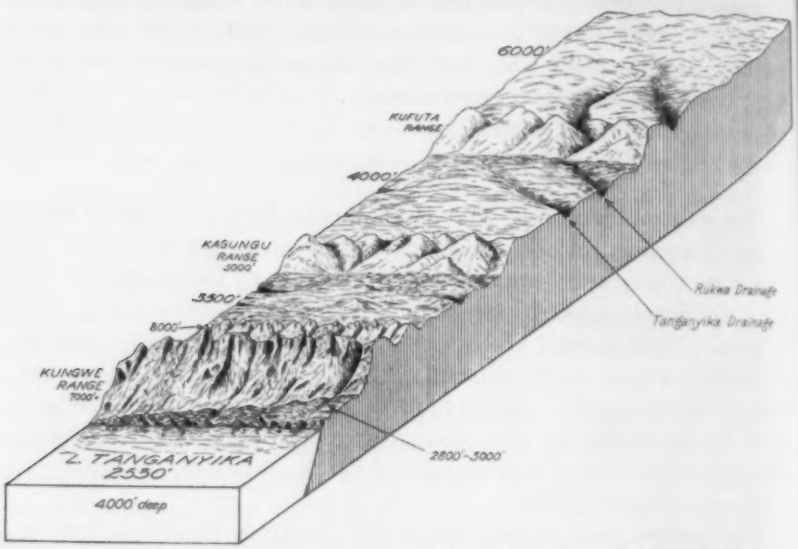

FIG. 3—Generalized block diagram of a section of highlands in the vicinity of the Kungwe Mountains east of Lake Tanganyika, showing strike-eroded topography disturbed by rift movements.

rising in many places to more than 4000 feet above lake level, there is a marked absence of the continuous straight, wall-like character that is displayed by many of the eastern rift scarps and by Rukwa close at hand. In the absence of a bathymetrical survey it is not possible to say what important features may be hidden beneath the surface of the deep waters. If Lake Rukwa were filled to the old shore line, no scarp would be visible on the eastern side, and the shore would then resemble more closely the type of the present Tanganyika shore.

Over a considerable extent of the country adjoining the eastern side of Lake Tanganyika there is evidence of an old pre-lake peneplain at 600 to 800 feet above the present lake level, into which all the streams have entrenched youthful gorges. Above the peneplain are numerous ridges and plateau blocks that rise from 1000 to 2000 feet above the old level and in some cases present steep faces to the margin of the lake. It would seem necessary to postulate that the lake must have risen at one time to at least 600 feet above its present level, when it was able to spill over and cut the still youthful gorge of the Lukuga in relatively soft sediments. If this is correct the lake would not have remained long at that level; but there is a marked absence of satisfactory evidence of old strand lines at or near that height.

The possibility of differential block movement around the margins of the lake needs looking into. At present the data are not sufficient. There would appear to be no evidence that the level of the water stood for any length of time below the present level for most of the streams enter the lake over bed rock at or close to the present shore line. One striking contrast in the topography around Lake Tanganyika with that along the Eastern Rift Zone is the greater relief and irregularity in all the features resulting from the fact that the Tanganyika trough was developed in a highland area of great variety and less mature peneplain development than that of the Central Zone.

Geomorphological History

A consideration of the long chain of events that has led up to the existing land forms of the Territory opens up many debatable questions, many of which involve correlation and discussion of the paleogeography of Africa as a whole, but particularly of Central and East Equatorial Africa. Considerable advance has been made regarding this aspect in Uganda by Wayland and Combe, and in Kenya by Leakey and Nilsson on the subject of late Tertiary and Recent conditions.[7] Less detail is available in this Territory, but there is promise of a rich harvest to the worker who has the time, training, and means to attack it. This was recently illustrated by the wonderful results obtained by Leakey, Reck, and Hopwood at Oldoway.[8] The following brief outline of the probable course of events will, it is hoped, serve to attract attention to a tempting field of research.

It will be sufficient here to start with post-Karroo or late Mesozoic times, when the long-continued and widespread sedimentation, chiefly in continental lake basins, came to a close and a new era of igneous and tectonic activity was ushered in. The Karroo basins of the coastal region became submerged partially, if not entirely, to at least 90 miles from the present coast line until late Tertiary times, when steady and continued uplift succeeded. The Recent period has been marked by slight oscillations, the most important being a marginal drowning which has formed the useful harbors of Tanga, Dar es Salaam, and other similar inlets along the coast.

In the interior of the Territory there are no post-Karroo fossiliferous sediments of proved age older than Pleistocene. There is, therefore, an enormous hiatus in the geological record. Deposits in Nyasaland, Kenya, and Uganda carry one back a little further, certainly to Pliocene, probably Miocene, and perhaps in Nyasaland to late Cretaceous. Apart from this evidence one is driven back to consider morphological features.

[7] Summary of Progress of the Geological Survey of Uganda for the Years 1919 to 1929, Uganda Protectorate, Entebbe, 1931.

[8] *Nature, loc. cit.*

While the coastal regions were being downwarped in Jurassic and Cretaceous times, there was probably a wide continental upwarping of the inland region accompanied by some block-faulting which let down parts of the Karroo strata into the ancient Basement Complex on which they had been deposited. Peneplanation continued to an advanced stage, removing most of the remaining Karroo deposits. Relics are preserved as ridges and dissected blocks rising from 800 to 1000 feet above a much more perfectly preserved peneplain, which in the least disturbed region of the central section lies at a present altitude of 3500 to 4000 feet. This younger peneplain was the result of renewed uplift with a period of widespread stability in what was probably Miocene time.

Slight warping, forming shallow basins, introduced a period of increasing tectonic activity which began to lay out the main lines of our present topography. Probably the drainage was of a normal continental type with an uninterrupted though sinuous Atlantic-Indian Ocean divide, situated along what is now the site of the Central Rift Zone.[9] As tectonic disturbances became more intense the upwarping of the eastern and western highlands with wide shallow downwarping of the great central region developed, and the troughs of the western lake zone began to make their appearance. Volcanic eruptions, which had previously broken out in several widely separated regions and then suffered a period of quiescence, began to renew their activities round or near the old centers. Troughs deepened, highlands continued to rise, and the old drainage systems were seriously interfered with. The original Rukwa and Eyasi dischargeless basins had already captured much of the oceanic drainage, which they still hold; while drowning of topography started in the Lake Victoria region and probably formation of a large shallow lake over the site of the Malagarasi swamps, which may have had a connection through to Lake Victoria and thence to the Nile for a time, as suggested by Gillman, though this is not certain.

The first pluvial period of Pleistocene times provided water that filled troughs and basins, some of which overflowed and reëstablished connection with oceanic drainage, as in the case of the Ruaha to the Indian Ocean and the Malagarasi swamps to Lake Tanganyika and the Congo and Atlantic. Then followed a succession of alternately dry, wetter, and dry cycles with the final result that all the great inland sheets of water have reached their present level.[10] In places,

[9] The writer here follows Krenkel in calling this the "central zone," which is correct for this Territory. It is continuous with the eastern rift zone of Kenya. The eastern tectonic zone, so well developed in this country as the Kaguru-Usagara Highlands and the Kilombero-Turiani scarp, is not represented in Kenya.

[10] A study of the present-day cycles of rise and fall of level of the lakes provides material for the consideration of important problems of meteorology and has a direct bearing on lake commerce and navigation. A review of these aspects with reference to Lake Tanganyika has been recently prepared by C. Gillman and will appear as one of the Geological Survey Bulletins.

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notably the Rukwa, Ruaha, Wembere, Eyasi, Oldoway, and Manyara basins, the old lake strata record striking evidence of the Pleistocene climatic changes. The present local base levels have had a marked influence on the adjacent topography by the active rejuvenation of stream activity which has advanced into the older levels to a degree varying with the resistance offered by the various formations, although even in the softest it is of striking youthfulness.

One of the latest episodes is renewed tectonic disturbance along the Central Rift Zone, where faulting with a throw of some hundreds of feet has dislocated the very youngest of the Pleistocene lake deposits and young ash beds. Frequent tremors along both the western and eastern zones indicate that adjustments are still proceeding. The existence of lake basins, dislocated topography, and disturbed river systems, as well as the unadjusted character of the topography generally, provides striking evidence of the persistence of tectonic activities until the present time.

ST. CROIX: A MARGINAL SUGAR-PRODUCING ISLAND

Earl B. Shaw

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IN the upward stage of the business cycle the marginal producer may share in the profits of industry: if, however, the cycle continue through a period of overproduction, sharp competition, and low prices, his profits rapidly disappear. This is the situation in the cane-growing island of St. Croix. A few figures suffice for the general situation. The world production of sugar virtually doubled in the last decade—18,000,000 tons in 1920–1921; 30,000,000 tons in 1930–1931.[1] Paralleling this expansion the price of sugar declined from an average of 12.06 cents (c. i. f. New York) a pound in 1920 to 1.33 cents in 1931 and in 1932 reached a record low price of 0.57 cents.[2] The crisis renders more acute a development that had already begun in St. Croix, a development in which geographical factors play an important part.[3]

St. Croix has long had a close association with sugar: it was the island's first money crop, and it continues to dominate the economy of the island after two hundred years of production. In early days high prices and slave labor enabled even the more rugged Virgins, St. Thomas and St. John, to share in the industry. At the close of the eighteenth century more than 30,000 acres in the islands were under sugar.[4] When markets fell in response to the increase of beet sugar and the severe competition of East Indian areas only regions topographically suited to machine cultivation and supplied with cheap labor could continue profitably. At present St. Croix produces all the Virgins' sugar, and the output continues to decline. According to the census of 1930 the crop of 1929 occupied 5823 acres and yielded a harvest of 56,400 tons, whereas in 1917, when the United States acquired the island, the harvest was more than 84,000 tons. St. Croix cannot compete with the world's leading low-cost cane producers. The limiting factors will now be discussed.

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[1] A. de Graaff: Die Neugestaltung der internationalen Zuckerwirtschaft, *Weltwirtschaftliches Archiv*, Vol. 37, 1933, pp. 255–281.

[2] J. C. Clifford: Sugar Industry Faces Sweeter Prospect, *Magazine of Wall Street*, Vol. 51, 1933, p. 676.

[3] On the operation of geographical and political factors in the sugar industry, see C. J. Robertson: Geographical Trends in Sugar Production, *Geogr. Rev.*, Vol. 22, 1932, pp. 120–130.

[4] Waldemar Westergaard: The Danish West Indies Under Company Rule (1671–1754) with a Supplementary Chapter, 1755–1917, New York, 1917. St. Croix had 27,655 acres under sugar: St. Thomas, 2496 acres; St. John, 1863 acres.

Rainfall as a Limiting Factor

Insufficient precipitation has always been the chief limiting factor in the sugar industry of St. Croix; and, in general, production has risen and fallen with the amount of annual rainfall (Fig. 1). For what is termed an average crop at least 45 inches of well distributed

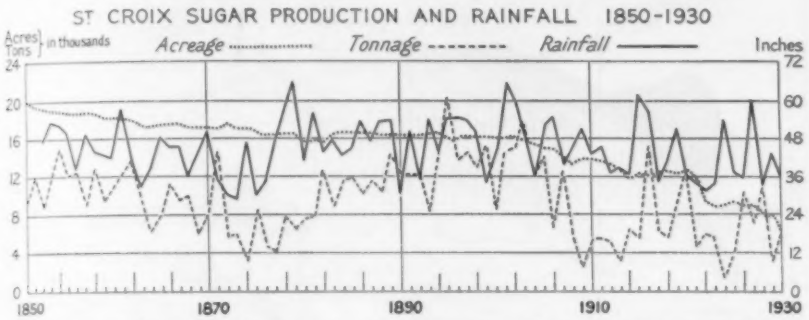

FIG. 1—St. Croix sugar production and rainfall, 1850–1930. Years of heavier sugar production generally follow those of high rainfall. The area under sugar showed a gradual decline from about 20,000 acres in 1850 to about 16,000 in 1900. Since then the decrease has been rapid until in 1931 it dropped below 5000 acres.

rainfall is necessary, and from 50 to 60 inches is required for a good yield.[5] Records for eighty years show that only during forty-three years was the mean annual rainfall 45 inches or more, whereas during the remaining years the amount ranged down to 29.48 inches, the total for 1873.[6] Incidentally it may be noted that the rainfall for 1931 established a high record—69.81 inches.[7]

Not only is the yearly total inadequate, but the distribution throughout the year is not dependable. A yearly precipitation of 50 inches or more is enough for a good crop if rightly distributed; but if approximately one-fourth to one-third comes during a single month, as it often does as a result of hurricane influence, and if the balance is not well apportioned, the mean annual figure has little significance. In contrast, the rainfall of Cuba has a high degree of dependability during the crop-growing season.[8]

The number of rainy days is likewise apt to be somewhat misleading. A monthly average of twelve to fourteen days with precipitation during the cane-growing season[9] suggests optimum weather

[5] The average production for plant cane is 17 tons an acre, ratoon cane 8 tons an acre. These averages and rainfall requirements for "good" and "average" crops were furnished by Glen Briggs, Director, U. S. Agricultural Experiment Station, St. Croix.

[6] Climatic statistics were furnished by the U. S. Weather Bureau, Washington, and the U. S. Agricultural Experiment Station, St. Croix.

[7] Earl B. Shaw: St. Croix's Rainiest Year Causes an Epidemic of Malaria, *Science*, Vol. 76, 1932, pp. 566–567.

[8] Oliver L. Fassig: Rainfall and Temperature of Cuba, *Tropical Plant Research Foundation Bull. No. 1*, Washington, 1925.

[9] W. W. Reed: Climatological Data for the West Indian Islands, *Monthly Weather Rev.*, Vol. 54, 1926, pp. 133–160.

for sugar. Often the rains are too light to reach the roots of the cane, and the limited quantity nullifies the ostensible advantage of short intervals between showers.

The causes of the unsatisfactory rainfall régime are to be found in a combination of circumstances. The convectional rain that reaches

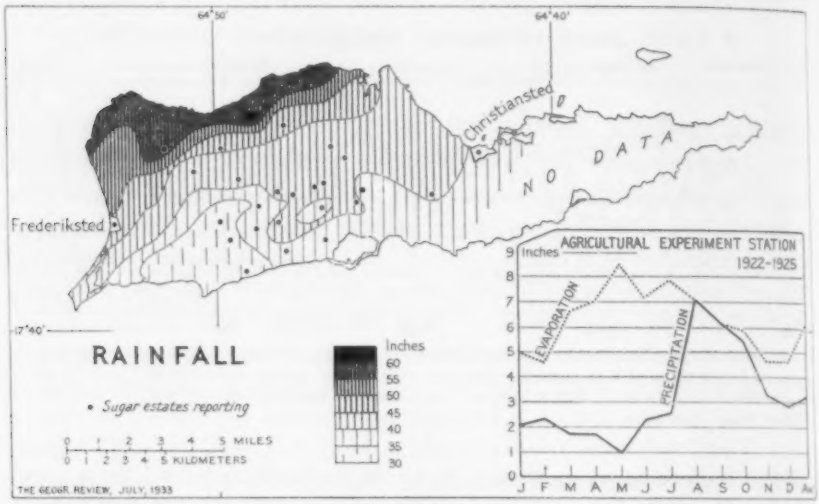

FIG. 2—Rainfall map of St. Croix. Rainfall records for a ten-year period from twenty-five stations were used. The eastern part of the island, which is known to have a comparatively low rainfall, is excluded, for only a single station with a year's precipitation was available.

Inset is a graph illustrating the typical rainfall régime and showing the relation between rainfall and evaporation at the St. Croix Agricultural Experiment Station (see Fig. 4).

a maximum at the time of the high sun is variable in occurrence and, because of the small size of the island, is seldom heavy. The hurricane control, a principal influence in the rainiest period, is likewise erratic. The northwest upland is insufficiently elevated to present an effective barrier to the northeast trades; and, in so far as the sugar lands are concerned, they receive no benefit except a slight increase from drainage, for they lie in the lee of the hill land.

Winds are another element that proves a hazard. Tropical hurricanes, at any time between May and November, may damage the growing cane or ruin it entirely. The constant trade winds, furthermore, encourage a high rate of evaporation—a climatic element unfavorable to moisture conservation. Measurements over a period of four years (1922–1925) indicate that the possible evaporation exceeds mean annual rainfall by an average of 36 inches (Fig. 2).

Topographic Limits of Machine Cultivation

Whereas climate affects adversely the possibilities for cane growing in the entire island, topography places definite limits to the area of machine cultivation (Fig. 4). Topographically St. Croix may be

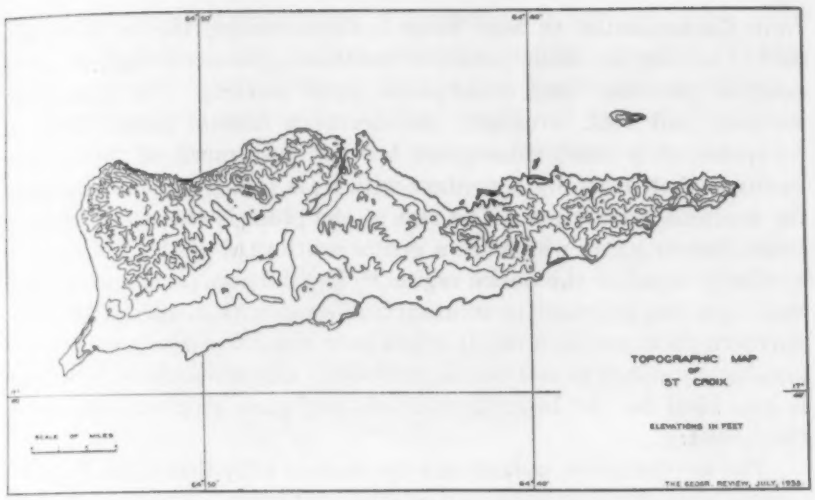

FIG. 3

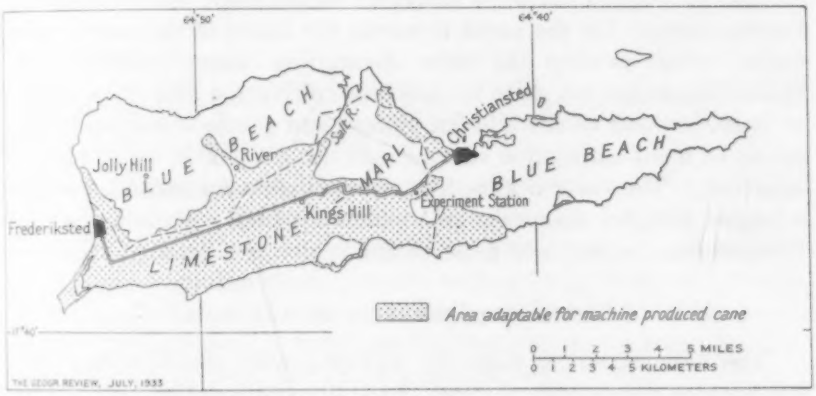

FIG. 4

FIGS. 3 and 4—Topography and rock formations. The topographic map shows the 100- and 200-foot contours, and thence the interval is 250 feet. The northwestern upland and the eastern hill land correspond generally with the "blue beach" formation (limits shown by dashed line); the central and southwestern coastal plain corresponds with the limestone-marl formation. The area suitable for machine cultivation agrees closely with the plains region, excluding the arc-shaped cuesta in its northern part.

divided into a central and southwestern section composed of a nearly level coastal plain, which rises to an arc-shaped cuesta in the north-central part, a northwestern upland area, and an eastern hill region.

The central and southwestern coastal plain contains the larger sugar lands (Fig. 5). The north-central part of this section, however, contains some hilly land that does not lend itself to machine cultivation. Differences in the physiographic history of the two parts of the plain account for this difference in topography. After the emergence of the Tertiary coastal plain, slight warping and erosion produced the cuesta in the north with an axis trending approximately northeast

from Christiansted to Salt River. Furthermore, the rocks of this arched section are semicrystalline limestones, porous enough to retard solution processes and consequent rapid leveling. As a result of warping and rock structure, the northern coastal plain, with the exception of a small subsequent lowland just north of the arcuate cuesta and structurally accordant with it, is topographically unsuited for machine production. The rest of the plain is characterized by a basin-like structure which has a gentle southward pitch similar to the southerly trend of the entire region.[10] In addition, its limestones and marls are less resistant to solution and erosion than the rocks of the northern part, and as a result it has been worn down to a stage topographically suited to machine agriculture. The levelness of its terrane is also ideal for the building of roads and cane railroads that serve the industry.

The northwestern upland and the eastern hilly belt differ from the coastal plain in topography and geologic structure. The northwestern section is a rugged maturely dissected region made up of folded Cretaceous rocks. On the north it marks the limits of the coastal-plain rocks, which overlap the older formations unconformably. The upland slopes are too steep for machine cultivation and are in pasture or bush.[11] Some of the alluvial valleys and gentle slopes lend themselves to hand cultivation of cane and are planted in small plots by squatters. The eastern hills, like the northwestern upland, comprise a rugged complex mountain area which has been maturely dissected. Precipitation is less, and most of the region has grown up in bush.

Merits and Demerits of the Soils

The soils are not so niggardly as topography and climate in their influence on the growth of cane. In many respects they are actually favorable, yet in some they leave much to be desired. The cane section lies largely within one of the three principal soil groups, that of the marls. The other two are the so-called blue beach and the alluvial-coastal plain soils. The marl group includes residual materials derived from the Tertiary limestones, which occupy the south-central part of the island. Favored by smooth topography and productive soils, this section includes St. Croix's best agricultural land. The better marl types yield rich surface soils of granular texture, good tilth, and a depth of nine inches or more. Beneath the surface soil there is a thin transition zone of mixed organic matter and marly lime, which is underlain by soft marly lime at shallow depths. In a

[10] H. A. Meyerhoff: The Physiography of the Virgin Islands, Culebra and Vieques (Scientific Survey of Porto Rico and the Virgin Islands, Vol. 4, Part II), New York Academy of Sciences, 1927, pp. 159–170.

[11] The term "bush" is a local word applied to a type of vegetation containing many species of trees and shrubs strongly armed with needle-like, piercing spines and prickles. Following Schimper's classification, the writer classifies much of the bush, especially in eastern St. Croix, as "thorn woodland."

few places local accumulations of sodium carbonate or other salts limit production. The surface soils have good moisture-holding capacity, but the marly lime is so porous that the subsoils do not hold moisture over long periods.[12] Their porosity is a distinct handicap,

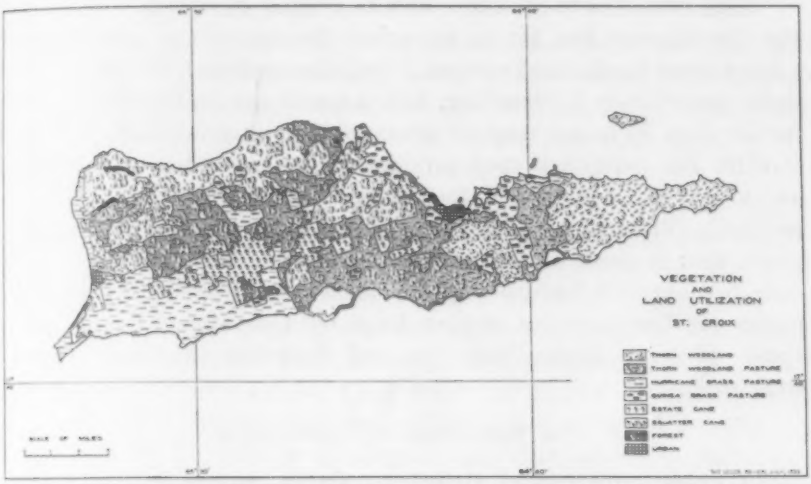

FIG. 5.—Land utilization and vegetation, St. Croix. The land in cane is only one-fourth of the sugar area of 1850 and less than one-third that of 1900. Thousands of acres of land ideally suited to machine cultivation are now given over to cattle raising.

but the marls are capable of supporting excellent crops of cane when moisture conditions are favorable.

There is a small region around River and Fountain estates with soils derived from dioritic or granitic rocks of late Mesozoic or early Tertiary age. This area, because of the granular texture of the rocks, has been eroded into a small lowland section surrounded by blue beach to the east, west, and north and marl to the south. In general, this is a productive cane area.

The blue beach residual soils are formed from rocks consisting of andesitic volcanic types and sedimentaries derived from them, together with small areas of limestone and shale. They cover more than half the land area of St. Croix, including the rugged northwestern highland and the eastern hilly section. It is rather the rugged topography that prohibits their use for machine culture than any natural unproductivity of the soils themselves. Indeed, on areas with less relief in the northwestern section, squatters cultivate small cane plots by hand.

The alluvial-coastal plain group consists of transported soils of two types: the alluvials found in the valleys of the intermittent streams—there are no perennial streams in St. Croix—and the coastal plain soils along the more open sections of the coast. The former

[12] James Thorp: Soil Survey (Reconnaissance) of St. Croix Island, Virgin Islands, *U. S. Dept. of Agric., Technical Bull. No. 315*, Washington, 1932.

are used to some extent for cane, but the latter receive little cultivation. There are also alluvial deposits around some of these open coastal areas, and it is difficult in places to draw a definite line of demarcation between alluvial and coastal-plain soils.

With reference to St. Croix soils as a whole it should be noted that the dry climate has led to imperfect decomposition, and this has caused some mechanical erosion. Yet, the moderate rainfall provides little opportunity for leaching, and the soils are fundamentally more fertile than in many tropical areas of heavier precipitation. Their fertility has permitted cane production for more than two hundred years without commercial fertilization and with little diminution in yield. Yield of sugar per acre is as high as it was two hundred years ago: it must be remembered, however, that improvements in cane manufacture have brought about a larger sugar extraction and higher-yielding varieties of cane have been developed from time to time. Hence it seems likely that soil depletion has taken place to some extent.

No Recourse in Irrigation

In many countries of deficient rainfall, reservoir or deep-well irrigation permits profitable crop production. However, an artificial water supply does not seem feasible in St. Croix. Recent reservoir-irrigation studies have suggested River, Jolly Hill, and Salt River areas as possible sites; but there are many discouraging factors. In each case only a small drainage basin is commanded, and the reservoir, of necessity located in a comparatively low-lying area and offering a large surface in relation to depth, would be subject to maximum evaporation. Besides, the potential area of cane land that might be benefited by such reservoirs is too small to justify the expense involved.

No less discouraging are the prospects for deep-well irrigation. Most geologists have reported adversely, and even those who are mildly encouraging suggest that such a supplement to natural precipitation will increase the moisture available for cane growing only by ten per cent of the total precipitation. A portion of the seepage from the northwest upland, where precipitation is heaviest, flows underground along the contact between a Tertiary basal conglomerate and the underlying Cretaceous volcanics and folded sediments. Wells sunk to this level will probably intercept the water, but even the ten per cent increase in moisture which may be recovered would not provide ample water for the sugar crop. Furthermore, the whole island is slightly tilted, and the limestone strata dip gently to the south. The dip increases materially the depth of the wells toward the coast; not many borings could tap the water-bearing horizon in less than three or four hundred feet. Once the water-bearing strata are reached, they will yield only the water that has seeped through

from the St. Croix drainage area; for the island rests on a high submarine platform that is separated from the other Antilles on all sides by very great depths. These facts afford little basis for any hope that the moisture for cane production can be increased adequately from reservoirs or deep wells.

Although there has been no advance in the control of the island's water supply, progress has been made in the control of insects and disease pests that prey on the cane. The St. Croix agricultural experiment station agronomist in his 1924 report indicated that the crop was comparatively free from disease;[13] and, as no mention has been made of insect or disease damage in any following report, it may be inferred that though potentially a hazard such damage has actually been of little moment in recent years. The aridity that handicaps a flourishing cane growth is probably a factor in limiting the loss.

Transportation costs furnish another handicap for St. Croix sugar producers. Although the anchorage at Christiansted is in a basin protected from the sea by Long Reef and Scotch Bank, a tortuous channel leads through the reef. The basin can accommodate only shallow-draft vessels at a considerable distance from shore, and lightering is necessary. Frederiksted, the chief commercial town, is little better off. It is situated on an open roadstead, and deep-draft vessels can anchor at a short distance from shore. The amount of the island's commerce does not warrant the construction of a pier, and freight and passengers must be lightered to and from steamers just as they are at Christiansted.

Unfavorable Economic Factors

To the physical handicaps certain economic handicaps are added. Labor has always given trouble to the sugar producers. It was important even in the early days when slave insurrections occurred; and the emancipation of the slaves in 1848 seriously crippled the industry for the time. The government of the islands, attempting to alleviate this handicap, created a condition of virtual slavery by means of contract and colonization systems, by the importation of cheap labor from the British West Indies, by drastic penal restrictions, and by the use of free rum. This situation existed until the close of the nineteenth century, when labor vigorously opposed existing conditions. Offered higher wages in outside areas, many of the laborers emigrated. Work on the Panama Canal and on the various Caribbean fruit and oil developments attracted some, and with the purchase of the island by the United States in 1917 the favorable emigration laws and a large demand for labor in that country accelerated the general exodus.

[13] Maybin S. Baker: The Sugar Industry in St. Croix, *Rept. Virgin Islands Agric. Exper. Sta., 1924*, Washington, 1925, pp. 16–19; reference on p. 19.

During the World War the limited number of workers gained the "whip hand," and strikes brought them concessions. Shortage of help continued, in fact, as a problem until the coming of the depression. The class of labor, furthermore, is inefficient; and at the prevailing wage of twenty to thirty cents a day St. Croix labor is fully as expensive as that in the United States.

The small size of the sugar centrals further increases expenses. Limited capacities and failure to operate at capacity bring a high overhead charge in manufacture. Two of the three centrals have seasonal capacities of only 25,000 tons of cane, and the third is but slightly larger. These figures contrast markedly with those of Cuban and Puerto Rican plants, some of which grind from 8000 to 10,000 tons of cane a day.

The advent of prohibition aggravated the sugar situation. Before 1920 St. Croix had an important by-product in the manufacture of her well known rum. Even this advantage was lost. The many disadvantages from which St. Croix sugar suffers are partially compensated by the boon of tariff-free entrance to the continental United States, the world's greatest sugar market. Only by means of this advantage has the industry struggled through the last decade. Whether sugar will continue to dominate St. Croix's exports depends largely on the persistence of present price conditions. If markets remain depressed, the industry will probably decrease further.

THE QUANTITATIVE STUDY OF EROSION TECHNIQUE AND SOME PRELIMINARY RESULTS*

H. H. Bennett
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THE beginning of the national program of research pertaining to soil and water conservation inaugurated in 1928 by the United States Department of Agriculture, in coöperation with individual states, had as its incentive a large store of accumulated information showing that soil depreciation and even complete devastation of the land by erosion were proceeding at a menacing rate in many parts of the country. For illustration of this "most serious cultural problem confronting the users of land" one may turn to the writer's paper on "The Geographical Relation of Soil Erosion to Land Productivity" in the October, 1928, number of the *Geographical Review*.[1] Some account will here be given of the investigations already conducted by the Bureau of Chemistry and Soils. Thus far the Bureau has established ten major soil-erosion and moisture-conservation experiment stations. In addition, the University of Missouri has a station near Columbia, Mo., and similar work is being done at the Texas Agricultural Experiment Station at Spur. These stations and the chief erosion regions are shown in Figure 1. The approximate areas of the erosion regions are given in Table I, together with estimates of the areas of formerly cropped land devastated to the extent of more than 34 million acres, and severely impoverished land to the extent of not less than 125 million acres.

Scope of the Investigations

A working plan for study of processes of erosion and run-off and methods of control had been drawn up by the writer in 1926.[2] This plan has been adhered to. Quantitative measurements of losses of soil, water, plant food, organic matter, and colloids are made by catching all the run-off from slopes of different gradients and lengths, using plots of as nearly uniform soil as can be found. In addition to analysis of annual composite samples from the several plots, indi-

*A condensed statement of a paper presented before the twenty-ninth annual meeting of the Association of American Geographers, Washington, D. C., December, 1932.

[1] See also H. H. Bennett: The Problem of Soil Erosion in the United States, *Annals Assn. of Amer. Geogrs.*, Vol. 21, 1931, pp. 147–170.

[2] See *Official Record*, U. S. Dept. of Agric., Vol. 5, No. 46, Nov. 17, 1926; *Journ. Amer. Soc. of Agronomy*, Vol. 23, 1931, pp. 357–371.

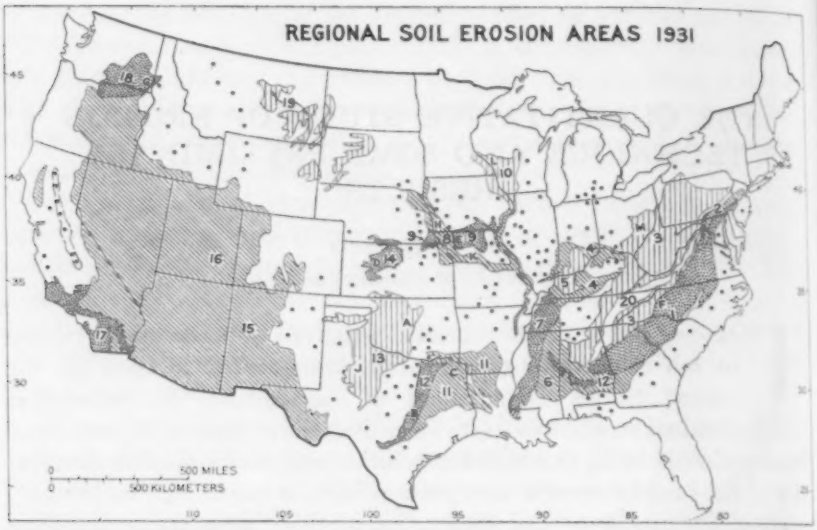


FIG. 1—Reconnaissance map of regional soil erosion areas, by the Bureau of Chemistry and Soils, 1931. Key to regions: 1, Piedmont Plateau; 2, Triassic region; 3, Appalachian Mountain region; 4, Illinois-Indiana-Ohio-Kentucky region; 5, Indiana-Kentucky region; 6, Mississippi-Alabama-Georgia Sandy Lands; 7, Southern Brown Loam region; 8, Northern Brown Loam region; 9, Iowa-Missouri region; 10, Southwestern Wisconsin; 11, Texas-Arkansas-Louisiana Sandy Lands; 12, Texas Black Belt; 13, Red Plains; 14, Western Kansas-Nebraska region; 15, Southwest valley grazing lands; 16, Southwest mountain grazing lands; 17, Southern California region; 18, Eastern Washington-Oregon Silty Lands; 19, Badlands; 20, Appalachian Valley. Dots indicate scattered areas.

Key to soil erosion and moisture conservation experiment stations: A, Guthrie, Okla.; B, Temple, Tex.; C, Tyler, Tex.; D, Hays, Kans.; E, Bethany, Mo.; F, Statesville, N. C.; G, Pullman, Wash.; H, Southwestern Iowa; J, Spur, Tex.; K, Columbia, Mo.; L, Southwestern Wisconsin; M, Northwestern Appalachians.

vidual samples following different seasonal conditions are analyzed to determine the effects of long dry periods, long wet periods, freezing, thawing, and other climatic conditions.

Complete physical and chemical analyses are made of the soil in each plot, horizon by horizon, from the surface down to 40 inches below the surface, at the beginning of experimental work. After this the surface horizon of each plot is analyzed annually for the purpose of progressively following up physical and chemical changes due to erosion.

Crops grown on uneroded and deeply eroded areas are compared not only as to yield but as to quality. The rate and cost of rebuilding soil from a condition of severe denudation are also measured by the use of the best known soil-improving crops for the various kinds of land under experimentation, as well as lime, manure, commercial fertilizers, and various forms of organic matter. The seasonal effects of tillage are investigated. In addition, the studies cover a wide range of soil modifications, such as subsoiling, strip subsoiling, and preparation of the seed bed in a rough cloddy, medium cloddy, finely pulverized and compacted condition, as well as scarification of the surface

TABLE I—PRELIMINARY ESTIMATE OF SOIL IMPOVERISHMENT AND DESTRUCTION BY EROSION
(*Areas in Acres*)

REGION AND SOILS	APPROXIMATE AREA OF REGION*	SEVERELY IMPOVERISHED OR SOIL WASHED OFF	DEVASTATED
Piedmont: residual timbered soils from igneous rocks (including Blue Ridge Mountains)	46,000,000	12,000,000	4,500,000
Triassic Piedmont: residual timbered soils from sandstone and shale	5,000,000	1,200,000	400,000
Appalachian Mountains: residual timbered soils, chiefly from sandstone, shale, and conglomerate	78,000,000	12,000,000	3,000,000
Illinois-Indiana-Ohio-Kentucky: timbered limestone soils	18,000,000	3,800,000	1,500,000
Indiana-Kentucky region: residual timbered soils, chiefly from sandstone and shale	7,000,000	2,500,000	500,000
Mississippi-Alabama-Georgia Sandy Lands region: from sedimentary deposits of coastal plain, timbered	27,000,000	6,500,000	2,000,000
Southern Brown Loam region: chiefly from loessial deposits, prairie and timbered	17,000,000	4,500,000	1,800,000
Northern Brown Loam region: chiefly from loessial deposits, prairie and timbered	18,000,000	2,500,000	350,000
Missouri-Iowa-Kansas-Nebraska region: mainly prairie soils from glacial deposits	11,000,000	4,500,000	350,000
Southwestern Wisconsin region: chiefly from loessial deposits, prairie and timbered	12,000,000	4,500,000	175,000
Texas-Arkansas-Louisiana Sandy Lands region: from sedimentary deposits of coastal plain, timbered	33,000,000	9,500,000	1,500,000
Texas-Alabama-Mississippi Black Belt: prairie soils from chalk and marl	12,000,000	4,500,000	1,000,000
Red Plains of Texas, Oklahoma, and Kansas: mainly plains soils, chiefly residual from sandstone and shale, partly timbered	36,000,000	15,000,000	3,000,000
Western Kansas-Nebraska region: residual plains soils	10,000,000	1,500,000	300,000
Palouse Wheat Belt: bunch grass soils, chiefly from loessial deposits	13,000,000	1,500,000	75,000
Limestone valleys and basins: chiefly timbered limestone soils (Great Appalachian Valley and associated areas)	22,000,000	11,000,000	3,500,000
Other areas widely scattered throughout the country, such as the Ozark region, the bean districts of California, the southeastern coastal plain, the glacial soils of Illinois, Michigan, Wisconsin, New York, etc., the Great Plains, and other regions	.....	28,000,000	5,250,000
Stream bottoms (detrimentally affected by overwash, channel filling, and increased overflow)	.....	.....	5,000,000
Total	.....	125,000,000	34,200,000

* See H. H. Bennett: The Soils and Agriculture of the Southern States, New York, 1921.

with holes intended to catch and retain part or all of the rain. Besides engineering structures, such as terraces and various types of dams, strip cropping, living dams of grass, trees, and vines, cover crops, crop rotations, and other control measures are being thoroughly tested as to their individual and combined efficiency and cost by the coöperating agencies.

The effect of these various treatments and engineering structures on penetration and retention of rain water are determined not only

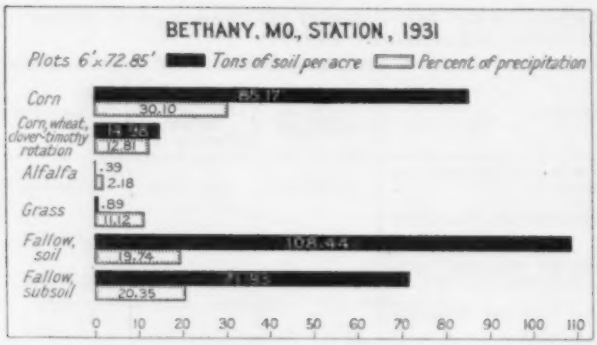


FIG. 2

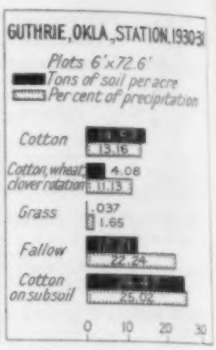


FIG. 3

FIG. 2—Soil and water losses at the Missouri-Iowa experiment station near Bethany, Mo. (E on Fig. 1), 1931. Soil losses are in tons per acre; water losses in percentage of the total precipitation. The plots were 6 feet by 72.85 feet on an 8 per cent slope of Shelby loam. The precipitation was 42.5 inches in 70 rains of which 31 caused run-off. The chief losses were caused by 8 of the rains, of which one of 1 inch caused the enormous loss of 19.5 tons of soil per acre on a plot devoted continuously to corn.

FIG. 3—Soil and water losses at the Red Plains station near Guthrie, Okla. (A on Fig. 1). This figure represents the average for 1930 and 1931 on a 7.7 per cent slope of Vernon fine sandy loam (timbered phase). The mean rainfall was 31.5 inches (33.7 in 1930; 29.2 in 1931). There were 135 rains, of which 37 caused run-off.

by actual measurement of the water contained in the soil material at different levels through the soil profile but also by the resultant crop yields. Moisture determinations are made at critical locations throughout the year, and losses of water and plant food by percolation. Erosion losses from cultivated and abandoned areas are determined, also, through surveys made by comparing the profiles of soils existing under such conditions with the profiles of virgin areas.

SOME EXAMPLES OF SOIL AND WATER LOSSES

The soil and water losses sustained with different vegetative covers under similar conditions of soil, slope, and rainfall are illustrated in Figures 2 to 7. Thus on the Shelby loam of the Bethany, Mo., station (Fig. 2) on land planted continuously to corn the loss of soil amounted to 85 tons an acre, and the run-off to 30 per cent of all the precipitation on a slope 72.9 feet in length. The loss from alfalfa grown under the same conditions immediately alongside, was only .4 of a ton of soil an acre, and the water loss amounted to 2.2 per cent of the precipitation. Where corn was grown in rotation with wheat and clover the losses were 57 per cent less with respect to soil and 25 per cent less with respect to water. This was in 1931: the beneficial effects of crop rotation showed up even more strongly in 1932, and where lime and superphosphate were applied the losses were still further reduced, the saving amounting to nearly five times as much soil and more than twice as much water.

On the Vernon fine sandy loam of the Oklahoma station grass

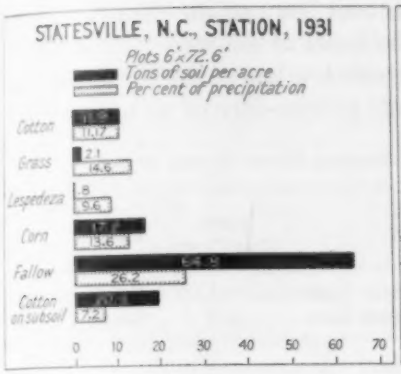


FIG. 4

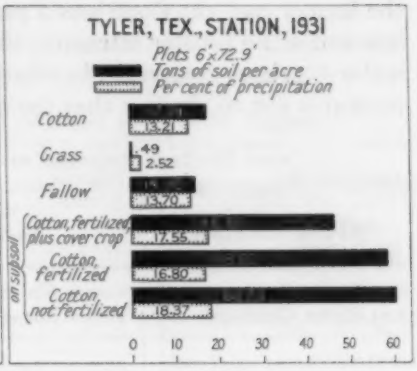


FIG. 5

FIG. 4—Soil and water losses at the central Piedmont station near Statesville, N. C. (F on Fig. 1), 1931, on a 10 per cent slope of Cecil sandy clay loam. The precipitation was 44.35 inches in 74 rains, of which 33 caused run-off.

FIG. 5—Soil and water losses at the Arkansas-Louisiana-East Texas station near Tyler, Tex. (C on Fig. 1), 1931, on an 8.75 per cent slope of Kirvin fine sandy loam. The precipitation was 36.1 inches (a 6.6-inch deficiency from the normal) in 56 rains, of which 36 produced run-off. Compare also Figure 6.

held back eight times as much of the rainfall and 393 times as much of the soil as land devoted continuously to cotton, while under a three-year rotation of cotton, wheat, and sweet clover there was a large reduction of erosion and some diminution of run-off. A remarkable instance of the enormous restraining effect of grass with respect to soil and water losses is recorded at the Kansas station at Hays (Fig. 7): in comparison with clean-cultivated Kafir corn, grass held back 4250 times as much soil and 399 times as much water.

The graphs also present examples of the soil variable. The large losses at the Missouri station are striking. Taking a specific instance, one may compare the losses from a clean-tilled crop (corn) on the Shelby loam of this station with a clean-tilled crop (cotton) on the Cecil sandy clay loam of the North Carolina station. Although in

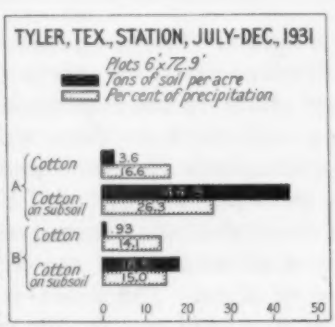


FIG. 6

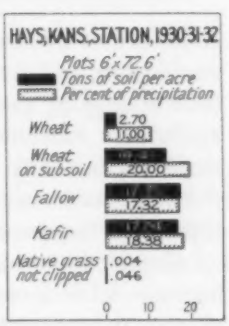


FIG. 7

FIG. 6—Soil and water losses at the Arkansas-Louisiana-East Texas station near Tyler, Tex., July to December, 1931. A represents losses on the Kirvin fine sandy loam on an 8.75 per cent slope; B represents losses on lateritic Nacogdoches fine sandy loam on a 10 per cent slope. The rainfall during the period was 19.2 inches. Compare also Figure 5.

FIG. 7—Soil and water losses at the western Kansas-Nebraska Plains station near Hays, Kans. (D on Fig. 1), on a 5 per cent slope of Colby silt loam. This figure represents an average for the three years 1930 to 1932; the mean annual rainfall for the period was 23.46 inches.

the former case the slope was 2 per cent less and the rainfall 2 inches less and of no greater intensity, the losses of soil were 7 times and of water 2.5 times greater. The relatively low loss at the North Carolina station is due to the fact that the old granite-derived soils of the Cecil

TABLE II—TIME REQUIRED TO REMOVE SEVEN INCHES OF SOIL

REGION AND STATE	SOIL	SLOPE (PER CENT)	CROP*	TIME (YEARS)
Red Plains, Oklahoma	Vernon fine sandy loam	7.7	Cotton	68
Red Plains, Oklahoma	Vernon fine sandy loam	7.7	Grass	26,621
Arkansas-Louisiana-Texas Sandy Lands, Texas	Kirvin fine sandy loam	8.7	Cotton	57
Arkansas-Louisiana-Texas Sandy Lands, Texas	Kirvin fine sandy loam	8.7	Grass	2,010
Central Piedmont, North Carolina	Cecil sandy clay loam	10.0	Cotton	76
Central Piedmont, North Carolina	Cecil sandy clay loam	10.0	Grass	464
Corn Belt, Bethany, Missouri	Shelby loam	8.0	Corn	11
Corn Belt, Bethany, Missouri	Shelby loam	8.0	Alfalfa	2,525
Corn Belt, Columbia, Missouri	Shelby loam	8.5	Corn	8
Corn Belt, Columbia, Missouri	Shelby loam	3.7	Corn	50
Corn Belt, Columbia, Missouri	Shelby loam	3.7	Grass	3,283
Kansas-Nebraska Region, Kansas	Colby silt loam	5.0	Kafir	58
Kansas-Nebraska Region, Kansas	Colby silt loam	5.0	Grass	246,250

*All crops grown continuously. No fertilization used except for alfalfa.

series are of a lateritic nature. The fine particles are slow to go into suspension, and the effective porosity exceeds that of similarly textured soils possessing greater plasticity and impermeability. This appears again in a comparison with the East Texas station. Although the slope at the North Carolina station is steeper and the rainfall heavier, the soil loss from the more plastic red clay of East Texas was three times and the run-off two and one-half times greater.

Comparisons show that erosion and run-off do not everywhere increase with increase of slope. The losses do increase, however, though not necessarily at a fixed rate, as the gradient increases for the same soil type where the rainfall and treatment are the same.

Thus the character of the soil is seen to exert a powerful influence

on the rates of erosion and run-off. This fact shows how important it is to take into consideration all the many variables affecting erosion processes before conclusive statements or formulas are drawn up.

TABLE III—RELATION OF LENGTH OF SLOPE TO RATE OF EROSION

REGION AND STATE	SOIL	CROP	EFFECTIVE LENGTH OF SLOPE (FEET)	SOIL LOSS (TONS PER ACRE)	WATER LOSS (PER CENT OF PRECIPITATION)
Red Plains, Oklahoma	Vernon fine sandy loam	Cotton	36.3	14.6	11
Red Plains, Oklahoma	Vernon fine sandy loam	Cotton	72.6	14.6	12
Red Plains, Oklahoma	Vernon fine sandy loam	Cotton	145.2	20.0	13
Central Piedmont, North Carolina . .	Cecil sandy clay loam	Cotton	36.3	13.8	14
Central Piedmont, North Carolina . .	Cecil sandy clay loam	Cotton	72.6	11.9	12
Central Piedmont, North Carolina . .	Cecil sandy clay loam	Cotton	145.2	18.2	10
Arkansas-Louisiana-East Texas Sandy Lands, Texas . . .	Kirvin fine sandy loam	Cotton	36.3	9.9	12
Arkansas-Louisiana-East Texas Sandy Lands, Texas . . .	Kirvin fine sandy loam	Cotton	72.6	17.2	13
Arkansas-Louisiana-East Texas Sandy Lands, Texas . . .	Kirvin fine sandy loam	Cotton	145.2	21.9	13½
Corn Belt, Missouri .	Shelby loam	Corn	72.6	85.2	30
Corn Belt, Missouri .	Shelby loam	Corn	145.2	105.8	28
Kansas-Nebraska Region, Kansas . . .	Colby silt loam	Wheat	36.3	2.3	11
Kansas-Nebraska Region, Kansas . . .	Colby silt loam	Wheat	72.6	2.7	11
Kansas-Nebraska Region, Kansas . . .	Colby silt loam	Wheat	145.2	3.2	10

It may be observed here that such a statement as "The power of moving water to scour or loosen soil particles varies as the square of the velocity, and the power to transport this material varies as the sixth power of the velocity" is in need of a rather stronger modification than the mere assumption that those who employ it in the sense of a fixed natural law speak from the premise of "other things being equal."

The soil losses illustrated graphically in Figures 2 to 7 may be compared in another way—by the time required to remove a given thickness of soil. This is shown in Table II.

Erosion Rate and Length of Slope

Another variable for which no simple relation can be stated is the length of slope. Table III suggests that loading and unloading processes with respect to the silt burden are involved in the progress of an eroding sheet of water on a slope. There is evidence that the unloading of suspended silt may proceed under some conditions to a point beyond the carrying capacity for the rate of flow at the time of deposition: for some unknown reason the water lays down more than its overload. This appears to be particularly true of certain soils, such as the extensive Susquehanna and Oktibbeha groups in the Gulf coastal plain region. On such soils zones of relatively high resistance to washing are of common occurrence in cultivated fields. Gullies developing above terminate in deltas along a definite contour. The tendency is so pronounced in some areas that use is made of it in the locating of field terraces. Even the smallest rills, with their diminutive depositional plains, are searched out as a guide in terracing.

Yields from Eroded and Uneroded Soil

Table IV shows a comparison of the yields from uneroded virgin soil (or soil but moderately eroded) and areas where all the soil was taken off down to the clay subsoil before measurements were made. Originally both the eroded and uneroded areas were precisely similar.

Erosion Surveys

Detailed erosion surveys have been made of the farms of all the ten erosion-research stations whose areas range from about 100 acres to more than 400 acres. Similar intensive surveys have been made also of a number of representative outlying areas. The Agricultural and Mechanical College of the State of Oklahoma has made a reconnaissance erosion survey of that state,[3] and the Bureau of Chemistry and Soils has completed one of the Brazos River watershed in Texas. This latter survey,[4] covering 27 million acres, shows that 20 per cent of the 9,250,000 acres of cultivated land has reached the stage of gullying, with 66 per cent, or 6,250,000 acres, suffering seriously from sheet washing.

The detailed erosion survey of 136 acres devoted to erosion studies on the Blackland Station, near Temple, Texas, shows that 74 acres have lost from 2 to 42 inches of soil and subsoil. Here the depth to comparatively unproductive chalk, the parent material of the rich black soil now gone along with the yellow subsoil, ranges from about 36 to 42 inches or a little more in the virgin areas. The results show that 83 per cent of the total area has lost an average of 2588 tons of

[3] See Bennett, The Problem of Soil Erosion in the United States, p. 157.
[4] From unpublished manuscript by H. V. Geib, of the Bureau of Chemistry and Soils.

soil and subsoil material an acre since the land was put under cultivation, some thirty to forty odd years ago.

About 7 million acres of the 11 million included in the Blackland Prairies of Texas consist of the limey Houston soils, along with some closely related types.[5] Soil surveys and erosion surveys indicate

TABLE IV—ACREAGE YIELDS ON ERODED AND UNERODED SOIL

CROPS	SOIL	STATE	UNERODED	ERODED
Cotton* (Seed)	Vernon fine sandy loam	Oklahoma	609 lbs.	309 lbs.
Cotton† (Seed)	Cecil sandy loam	North Carolina	1,219 lbs.	630 lbs.
Cotton (Seed)	Houston black clay	Texas	1,675 lbs.	210 lbs.
Cotton† (Seed)	Kirvin fine sandy loam	Texas	337 lbs.	33 lbs.
Corn	Shelby loam	Missouri	50 bu.	17 bu.
Corn	Houston black clay	Texas	34 bu.	5.7 bu.
Wheat‡	Colby silt loam	Kansas	25.2 bu.	4.8 bu.
Oats	Houston black clay	Texas	66.5 bu.	19.2 bu.

*Average of 4 years; †average of 2 years; ‡average of 3 years.

that considerably more than half of this has suffered as much proportionally as the Blackland Station. The indications are that during the past 35 years this one region—which is not the most erosive region of the country—has been losing soil at the average annual rate of 250 to 300 million tons. Such losses are not indicated by the measured discharge of silt into the Gulf of Mexico through the streams. The greater part of the soil swept off the slopes is temporarily stranded on lower slopes, over alluvial plains, and in the channels of streams. Much of the soil lost from the 74 acres of eroding land at the Texas Blackland Station has been deposited on the lower slopes, greatly increasing the depth of such areas, although not improving them, and it is as effectively lost as if it had in fact been dumped into the Gulf.

Vegetation surveys of virgin and severely eroded, abandoned Houston black clay reveal a tremendous difference with respect to plant cover. A typical area of virgin grassland in Bell County, Texas, for example, showed only 6 per cent of the ground surface as being bare of vegetation. Of the 94 per cent vegetated area, 93 per cent was covered with grasses and only 1 per cent with weeds. Another

[5] W. T. Carter: The Soils of Texas, *Texas Agric. Exper. Sta. Bull. No. 431*, 1932.

area of the same original soil, after a period of cultivation and erosion, had been changed to an entirely different soil and abandoned. This, although not cultivated or grazed for four years, showed 60 per cent of the surface as bare ground, 39 per cent covered with weeds, and only 1 per cent with grass. Of seven species of weeds on the abandoned area, but one was present in the virgin plant cover. A single species of grass only was found on the abandoned eroded land, as compared with eight species in the cover of the uneroded area.[6]

Conclusion

These investigations show that in any comprehensive study of rainfall efficiency the factor of run-off must be duly considered. Direct loss of water as run-off and decreased availability of absorbed moisture resulting from erosion-produced changes in the physical condition of the soil (changes in structural efficiency) are very pertinently involved with moisture efficiency.

The powerful restrictive force of thick-growing vegetation with respect to exposed sloping soil, and the capacity of such crops to reduce run-off, are revealed in the quantitative measurements presented above. The influence of soil, slope, crop, and cultural method is also brought out, as well as the depressing effect of erosion on crop yields. That erosion is much more widespread than commonly supposed is brought out in the regional estimates of land damage. The rapidity of the process in disposing of the more productive topsoil, especially with reference to certain peculiarly erosive types of land, is shown by the time requirements for effecting such disposal.

The significance of rainfall records does not necessarily accord with common interpretation of these data. For example, the interpretation of the average person with respect to the ultimate disposal of the 42 inches precipitation recorded at the Bethany, Mo., erosion station in 1931 probably would be that the ground soaked up for crop use these many inches of rain water. There would be little or no consideration of the following points: that in cornfields of the average slope nearly 13 of the 42 inches was lost as run-off; that, of the seventy rains recorded, thirty-nine were of such light character as to produce no run-off and were largely lost as evaporation; and that an undetermined amount of the precipitation was lost by percolation. In other words, it is not commonly understood that about half the precipitation falling on the average sloping land of a considerable part of the Corn Belt represents water that is irretrievably lost, chiefly by run-off and evaporation of light showers.

[6] These vegetation surveys were carried out in 1931, at the suggestion of the author, by H. V. Geib, of the Bureau of Chemistry and Soils, and Simon E. Wolff, of the Texas Agricultural Experiment Station. See H. H. Bennett: Relation of Erosion to Vegetative Changes, *Scientific Monthly*, Vol. 35, November, 1932.

THE CLIMATES OF THE EARTH

C. Warren Thornthwaite
University of Oklahoma

[With separate map, Pl. V, facing p. 440]

OF the various elements that constitute the natural landscape, climate is probably most readily adaptable to quantitative study, for the reason that climatic observations are made in numerical terms. Köppen was the first to apply to the entire earth a climatic classification based mainly on quantitative analyses of meteorological data. He recognized that the critical limits in the distribution of various types of vegetation were climatic and attempted to discover empirically climatic values that would at least approximately coincide with the various vegetational limits. He tried to determine minimum or maximum values of mean monthly, seasonal, or annual temperature and rainfall that might be said to account for limits of individual vegetation types. A further innovation of Köppen's was the use of a symbolic nomenclature in the designation of the individual climates.

A Quantitative Classification

The present classification is like Köppen's in that it is quantitative and attempts to determine the critical climatic limits significant to the distribution of vegetation and also in that it employs a symbolic nomenclature in designating the climatic types. It differs from Köppen's classification in that it makes use of two new climatic concepts, precipitation effectiveness and temperature efficiency. It is inferred that in the tropical rain forest, the most rapidly growing and the densest vegetation type on the earth, the climate must be the most favorable of all for plant growth. Temperatures are constantly high and rainfall is constantly abundant. Here, therefore, the precipitation effectiveness and the temperature efficiency must be at a maximum. Diminution of either element will produce conditions less favorable for the rapid development of vegetation. It is evident that precipitation effectiveness grades from a maximum in the tropical rain forest to a minimum approaching zero in the tropical desert and that temperature efficiency grades from a maximum in the tropical climate to a minimum at zero in the climate of perpetual frost. The vegetation transitions due to diminished effective rainfall are: (A) rain forest, (B) forest, (C) grassland, (D) steppe, (E) desert, and

those due to diminished temperature efficiency are: (A′) tropical rain forest, (B′) temperate rain forest, (C′) microthermal rain forest, (D′) taiga, (E′) tundra, (F′) perpetual frost (no vegetation). The dry or cold boundaries of any of these regions are critical climatic limits beyond which the vegetation type cannot go. Of course it is understood that because of edaphic, cultural, or historical factors vegetation types do not always extend out to their climatic limits.

Since the boundaries of the above-mentioned vegetation regions are thought of as the critical climatic limits, the attempt has been made to determine the actual numerical values of precipitation effectiveness and temperature efficiency that thus constrain the extension of the various types. The postulates on which the concepts of precipitation effectiveness and temperature efficiency are based, together with the rules established for determining their numerical values, have been presented and discussed at length in an earlier paper.[1] By use of these rules, indices of precipitation effectiveness (P–E) and temperature efficiency (T–E) may be obtained for any station whose mean monthly temperature and precipitation have been recorded.

Five humidity types have been recognized in the general classification. These types with their P–E ranges and characteristic vegetation are as follows:

Humidity Type	Characteristic Vegetation	P–E Index
A (Wet)	Rain forest	128 and above
B (Humid)	Forest	64 to 127
C (Subhumid)	Grassland	32 to 63
D (Semiarid)	Steppe	16 to 31
E (Arid)	Desert	0 to 15

It appears to be a fact, although not at present understood, that the limiting values are in a geometric progression, with an effective rainfall along the humid boundary twice as great as along the arid boundary.

The six temperature efficiency types with their T–E ranges follow:

A′	Tropical	128 and above	D′	Taiga	16 to 31
B′	Mesothermal	64 to 127	E′	Tundra	1 to 15
C′	Microthermal	32 to 63	F′	Perpetual frost	0

It is evident that when five humidity zones and six thermal zones are combined, thirty theoretically possible climatic regions result. In addition, seasonal distribution of effective precipitation was considered, and four types of seasonal distribution were recognized and defined:

r.....rainfall abundant at all seasons
s.....rainfall scanty in summer (abundant in winter)
w.....rainfall scanty in winter (abundant in summer)
d.....rainfall scanty at all seasons

[1] C. W. Thornthwaite: The Climates of North America According to a New Classification, *Geogr. Rev.*, Vol. 21, 1931, pp. 633–655.

A modification of the winter dry (w) type is recognized in certain tropical regions. Here the drought occurs in spring instead of winter, and the rainy season is in fall instead of summer. The type is designated as w′.

Three climatic factors are thus considered: (1) precipitation effectiveness, (2) temperature efficiency, and (3) seasonal distribution of effective precipitation.[2] These factors have five, six, and four aspects respectively, and each is designated by a symbol. There are 120 different possible combinations of these 15 symbols, making 120 theoretically possible climates. However, certain combinations of symbols are eliminated by definition; and others, being meteorologically impossible, do not occur anywhere on the earth; so that of the 120 possible combinations only 32 represent actual climatic types (see Pl. V).

Use of Critical Limits

It must be remembered that precipitation effectiveness and temperature efficiency as climatic phenomena are not uniform for individual areas but vary within the critical limits that bound them. Except in mountainous country this variation is gradual from place to place with no definite irregularities of variation. Consequently, in the absence of breaks in their distribution as far as these climatic elements themselves are concerned, zones can be established only on a purely arbitrary basis. Thus the necessity of establishing the climatic boundaries in terms of the critical climatic limits of vegetation becomes apparent.[3]

In the United States, precipitation effectiveness indices range from 1 in Brawley, Cal., to 295 in Quinault, Wash.; and temperature efficiency indices range from 18 in Foxpark, Wyo., to 144 in Key West, Fla. Greater extremes certainly occur in areas for which meteorological records are not available. The highest temperature efficiency index yet computed is 171 for Bonny in the Niger delta. Here the mean monthly temperatures range from 86.1° F. in September to 93.5° F. in March, and the mean annual temperature is 89.1° F. In both north and south polar regions there are extensive areas where the temperature efficiency index is 0; that is, where the mean temperature of no month is above 32° F.

When only five humidity zones are established with the total P–E index varying between 0 and 300, and with only six thermal zones

[2] In the original statement in "Climates of North America" a fourth factor, namely summer concentration of thermal efficiency, was employed. This factor is important; but, as it is practically impossible to combine more than three elements on the map, it has been omitted. Still other climatic factors, such as intensity or violence of rainfall, are important; but technical difficulties in cartography make it impossible to include them. See Stephen B. Jones: Classifications of North American Climates: A Review, *Econ. Geogr.*, Vol. 8, 1932, pp. 205–208.

[3] Since the distribution of soil, minor land forms, and drainage pattern are all controlled more or less by climate, these landscape elements are also utilized in establishing the critical boundaries of climatic regions.

established in a T–E range from 0 to 170, it follows that great variations exist within each zone. For instance, Tokepa, Kan., and Tampa, Fla., are both classified as CB′r; but the T–E index of Topeka is 66, and that of Tampa is 120. One station is near the minimum limit, and the other is near the maximum limit of the mesothermal zone. The P–E index of the stations, however, is the same, 62, practically the boundary between the subhumid and the humid zones, and consequently both

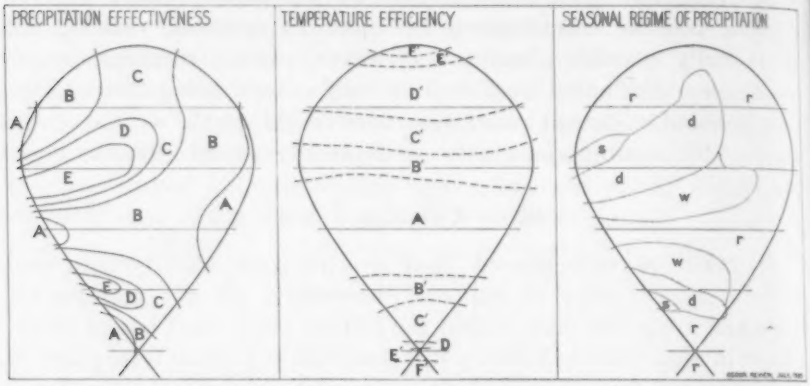


FIG. 1—Precipitation effectiveness, temperature efficiency, and the seasonal régime of precipitation on the generalized continent.

are in the tension zone between grassland and forest, where the actual vegetation developed may depend more on edaphic than on climatic factors.

It is in connection with the variation within regions that the importance of the P–E and T–E indices is seen, for they enable one to determine the position of the station within the climatic type. If the reality of critical limits in the vegetation can be demonstrated one is justified in placing together stations like Tampa and Topeka.

THE CLIMATES OF THE CONTINENTS

The distribution over the earth of the 32 different climates is shown on the world map, Plate V.[4] A study of the climates of the various continents reveals a very definite pattern or systematic arrangement in their distribution. The distributional pattern on the generalized continent of each climatic element is shown in Figure 1. The systematic arrangement of the climatic regions of the earth is generalized in Figure 2.

A summary of the areal extent of the eight great climatic types and the relation of the types to the total area of each continent is presented in Table I. The relative degree of accuracy of the classification in the

[4] The map is on Denoyer's semielliptical projection. This projection is not equal-area but the exaggeration of area becomes noticeable only in the polar regions.

grand divisions of the earth is extremely variable. Table I also shows the numbers of stations for which computations were made and the average number of square miles per station in each continent.

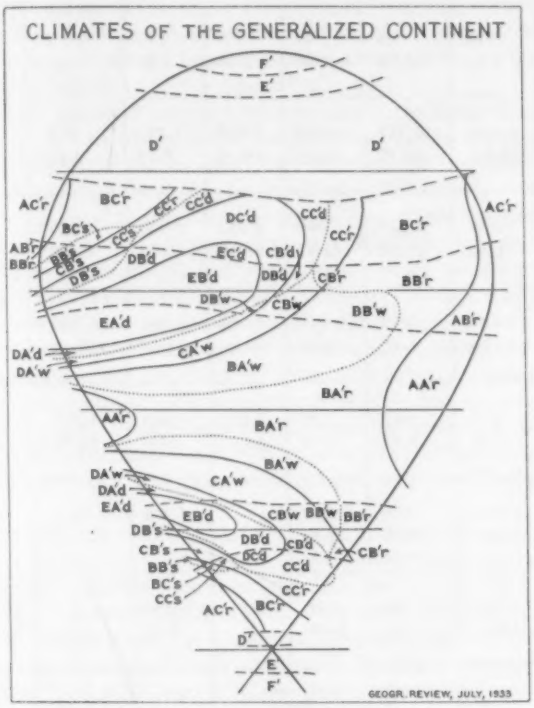


FIG. 2—Climates of the generalized continent.

NOTES ON THE MAP

The A Climates.—The rain forest climates are marine and are generally found at no great distance from the sea. All three types occur on both east and west sides of the continents of the northern hemisphere. In the southern hemisphere AB′r and AC′r do not occur on the east sides of continents and AB′r is lacking on the west sides as well. The true tropical rain forest, AA′r, is considerably less extensive over the earth than it is generally considered to be. In the western hemisphere it is found on the coast of the Gulf of Mexico in southern Mexico, in Central America, and along the northeastern coast of South America. In the eastern hemisphere the AA′r climate is found along the Guinea coast of Africa, on the east coast of Madagascar, along the west coasts of peninsular India and Burma, in the coastal parts of the East Indies and the Malay Peninsula, and in one small area on the east coast of Australia.

The AB′r climate is extremely limited in extent. It occurs only in northern California, on the peaks of the southern Appalachians, in Galicia in northwest Spain, and in the island of Kyushu in Japan. The AC′r climate occurs along the Pacific coasts of both North and South America, from California north to Alaska and from Valdivia south to the Strait of Magellan. It occurs also in the northern Appalachians and in Nova Scotia. In Europe it is found along the western coast of Ireland and the southwestern coast of Norway. In Asia the AC′r climate occurs only in eastern

TABLE I—CLIMATES OF THE CONTINENTS TOGETHER WITH THE NUMBER OF STATIONS USED AND THE AREA PER STATION

CLIMATES		NORTH AMERICA*	SOUTH AMERICA	EUROPE	AFRICA	ASIA	AUSTRALIA	ANTARCTICA	TOTAL
A	1000 *sq.m.*	175	203	22	106	781	9	.....	1,296
	%	2.13	2.83	0.58	0.96	4.82	0.32	.....	2.33
B	1000 *sq.m.*	1,439	3,257	729	1,888	1,417	284	.....	9,014
	%	16.65	45.36	19.25	16.59	8.75	9.55	.....	16.08
C	1000 *sq.m.*	1,287	2,340	1,660	3,283	2,699	530	.....	11,799
	%	14.89	32.58	43.81	28.78	16.64	17.80	.....	21.06
D	1000 *sq.m.*	1,142	665	177	2,286	3,403	846	.....	8,519
	%	13.20	9.26	4.68	20.10	21.01	28.44	.....	15.24
E	1000 *sq.m.*	378	447	46	3,839	2,461	1,306	.....	8,477
	%	4.36	6.22	1.22	33.57	15.20	43.89	.....	15.33
D′	1000 *sq.m.*	2,014	228	893	.....	4,023	.....	.....	7,158
	%	23.31	3.18	23.59	.....	24.81	.....	.....	12.79
E	1000 *sq.m.*	1,572	38	256	.....	1,422	.....	.....	3,288
	%	18.20	0.53	6.76	.....	8.77	.....	.....	5.88
F′	1000 *sq.m.*	628	3	4	.....	.....	.....	5,800	6,435
	%	7.26	0.04	0.11	.....	.....	.....	100.00	11.49
Total	1000 *sq.m.*	8,635	7,181	3,787	11,402	16,206	2,993	5,800	55,986
	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
STATIONS Number		3,289	189	137	176	150	65	OCEANIA 46	.....
Area per station *sq.m.*		2,440	36,000	27,000	65,000	114,000	45,000	.....	.....

* For the United States 2,854 stations were used, giving an area of 1,050 square miles per station. Data for stations in Canada and Mexico were kindly supplied by Dr. C. F. Brooks.

Siberia opposite the island of Sakhalin and on the west coast of Honshiu, the principal island of Japan. It is absent from Africa and Australia.

The B Climates.—The various forest climates have a greater proportionate extension in the western than in the eastern hemisphere. In South America BA′r and BA′w, with its autumn rainy modification, BA′w′, cover practically the entire Amazon Basin, and BB′r and BB′w most of southern Brazil. BB′s is found on the western flanks of the Andes in southern Chile. In eastern North America BB′r and

BC'r are found extensively: BB'r in the southeastern United States, and BC'r in the northeastern United States and southeastern Canada. In western North America BB's, BC's, and BC'r extend in a comparatively narrow strip along the Sierras and Cascades from southern California to central British Columbia.

In Africa BA'r occupies the entire Congo basin, and BA'w the portion of the Guinea coast not occupied by AA'r. Other forest climates in Africa are neither extensive nor varied. They are found generally either on the mountain slopes or on the coast and include BB'r, BB'w, and BB's.

In Europe BB'r and BC'r are the most extensive of the forest climates, although BB's occurs along the east shores of the Adriatic Sea. In the B climates of Europe the P–E index is ordinarily not far above 64, and in the curious westward extension of CC'r in northern Europe the P–E index is only slightly below 64. Thus practically all of northern and central Europe is in the tension zone where the actual vegetation, whether woodland or prairie, is dependent more on local edaphic conditions than on climate. Judging from the present P–E index, if the climate has not grown more arid since the period of great forest clearing in the thirteenth century, it seems that northern Europe was not so heavily forested as is popularly believed.

In Asia B climates are proportionately quite limited in extent. BA'w and BB'w are found in certain parts of the monsoon lands, and BB'r in Chosen and Honshiu. BC'r occupies the greater parts of Hokkaido and Sakhalin and occurs along the coast of the mainland opposite. The interiors of the larger islands of the East Indies have for the most part BB'r climates. In Australia BA'w and BB'r are found along certain sections of the north and east coasts. Tasmania and New Zealand have BB'r climates.

The C Climates.—Of the C climates those of summer rain and winter drought (CA'w and CB'w) are areally most extensive, occurring within the tropics in North and South America, in Africa, Australia, and Asia and beyond the tropics as far as latitude 40° N. in the monsoon lands of Asia. In western Brazil and peninsular India the autumn rainy modification, CA'w', occurs. The so-called Mediterranean climate (CB's), the summer dry mesothermal subhumid climate, is found only locally between latitudes 35° and 40° N. and S. on the west coasts of the continents extending into these zones. This climate is extremely limited in extent; and its microthermal aspect, CC's, is even less extensive, occurring only in the western United States.

CA'r is found only in certain islands of the West Indies and in a small area in west equatorial Africa, and CA'd is known to exist only in Key West, Fla. CB'r and CB'd occur in the southern Great Plains and prairies of the United States, in the pampa of Argentina, Paraguay, and Uruguay, in the plateau of eastern South Africa, in Europe in the Black Sea region, the lower Danube Valley, the Po Valley, and the lowlands adjoining the Pyrenees of Spain and France, and to a limited extent in southeastern Australia. CC'r and CC'd are found in the northern prairies and Great Plains of the United States and Canada, along the eastern slope of the southern Andes, in eastern Europe and in the London, Paris, and Hungarian basins, and in western Siberia and Manchuria in Asia.

The D Climates.—Six types of D climate have been recognized. The winter dry steppe has tropical and mesothermal aspects (DA'w, DB'w). The summer dry steppe is mesothermal only (DB's). As far as meteorological conditions are concerned microthermal summer dry steppe (DC's) should be found also, but no station having that classification has yet been studied. The steppe with rainfall deficiency in every season is found in all three thermal belts (DA'd, DB'd, DC'd).

All six types of steppe occur in North America, although only DB'd and DC'd are extensive areally. DA'd occurs at the end of the Yucatan Peninsula, and a small area of DA'w is found on the west coast of Mexico between 23° and 26° N. DB'w occurs on the northeastern part of the Mexican Plateau, and DB's in some of the valleys of southern California. In South America the D climates, with the

exception of a small area of DA′w′ in eastern Brazil, are localized in the rain shadow on the slopes of the Andes. Here DA′d, DB′d, DC′d, DB′s, and DB′w have developed.

In Africa DB′s lies along the northern margin of the Sahara, and DA′w lies along its southern margin. In South Africa much of the area generally called the Kalahari Desert is in reality DB′d.

The D climates are limited in variety and extent in Europe. DB′s and DB′d are found in the basins of the Spanish meseta and along the Mediterranean coast of Spain. DB′d is found also along the west coast of the Black Sea and with DC′d in southeastern Russia.

More than one-third of the area of Asia has E (arid) and D (semiarid) climates, and more than one-fifth has D climates. In fact nearly half of the total world area of D climate is in Asia. DB′d and DC′d are most important, extending from Asia Minor to eastern Manchuria. Areas of DA′w and DB′w are found on the borders of the Thar Desert in India.

In Australia the D climates border the great Australian Desert on three sides, with DA′w on the north, DB′d on the east, and DB′s on the south.

The E Climates.—Less than 5 per cent of the area of North America is desert, although all three types are represented. EB′d is most extensive and occurs in Mexico and the southwestern United States. A small area of EA′d occurs along the west coast of Mexico. EC′d is found in isolated sections in the central and northern parts of the western United States.

In South America about 6 per cent of the total area is desert. The Pacific coast between latitudes 10° S. and 32° S. is EB′d. East of the Andes a belt of desert, EB′d and EC′d, extends from 20° S. to the Strait of Magellan.

Desert climates in Europe are limited in extent (only 1 per cent) and occur as EB′d and EC′d only on the border of the Caspian Sea.

Two deserts of very unequal extent are found in Africa. The Sahara Desert (EA′d) of the north extends through 25 degrees of latitude and from the Atlantic to the Red Sea and comprises about 30 per cent of the area of the continent. The Kalahari Desert of the south also extends through about 25 degrees of latitude but is limited to a comparatively narrow strip, EA′d and EB′d, along the coast. More than 45 per cent of the desert area of the world is in Africa.

In Asia all three desert climates occur. Most of the Arabian Peninsula and the lower Indus Valley are EA′d. Throughout inner Asia and southwestern Asia the basins not too elevated are regularly EB′d and EC′d. Nearly 2,500,000 square miles of Asia's area are desert. Practically 44 per cent of Australia is desert (EA′d and EB′d).

The D′ Climates.—The two great areas of D′ climates are those extending across northern North America and northern Eurasia. Other smaller areas of D′ are found in the highlands of Europe, Asia, North America, and South America.

The E′ Climates.—The entire Arctic coast of Europe, Asia, and North America and the region inland for some distance is tundra. Much of the Tibetan Plateau and the higher parts of the Andes also are E′.

The F′ Climates.—Nearly all if not all of the continent of Antarctica has a climate of perpetual frost. The interiors of Greenland and Ellsmere Island also have climates that are continually below freezing.

CLIMATES

BY C.

AA'r 1 | BB'w 7 | CA'r 11 | CB'r 14 | CB's 16

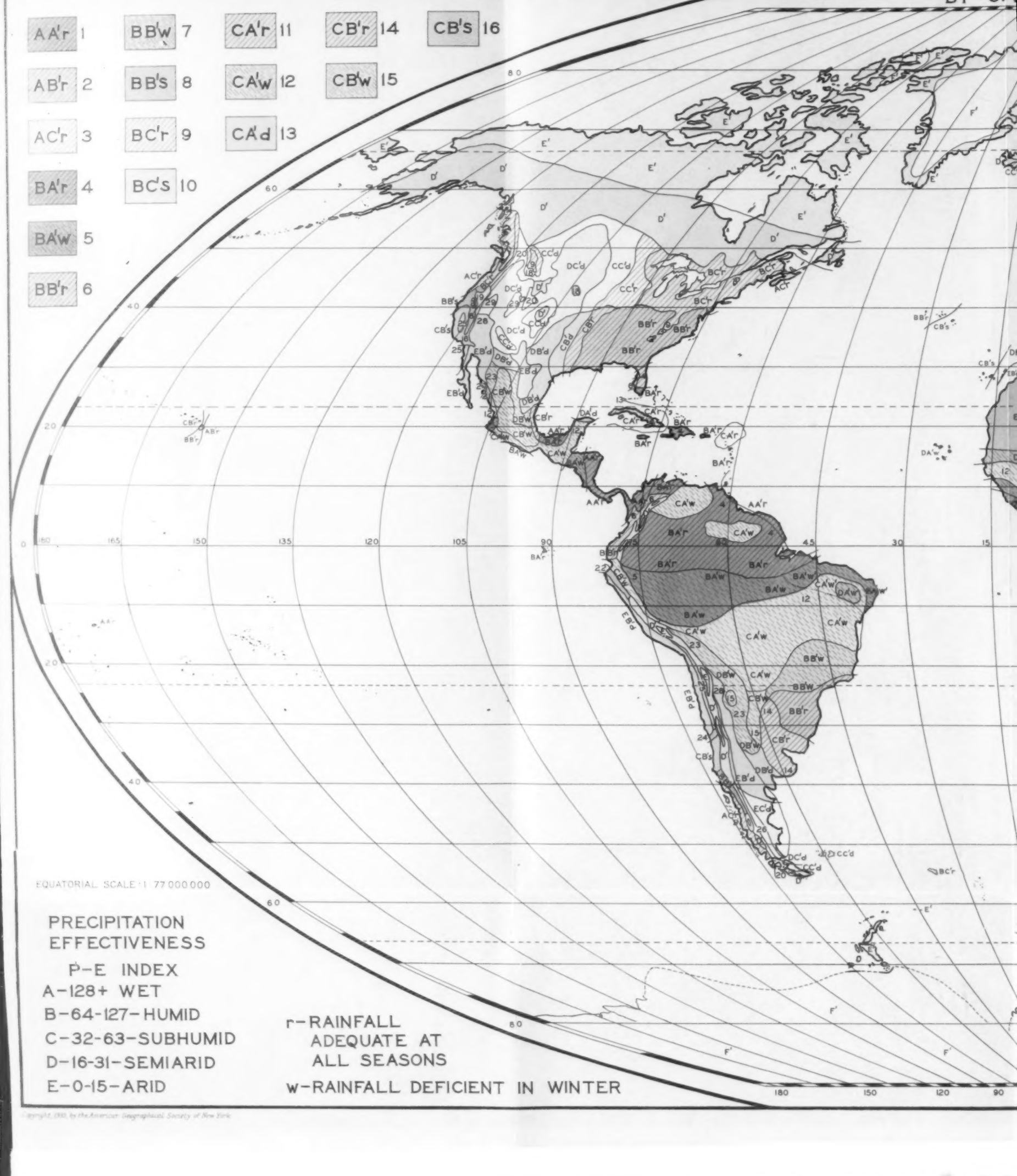
AB'r 2 | BB's 8 | CA'w 12 | CB'w 15

AC'r 3 | BC'r 9 | CA'd 13

BA'r 4 | BC's 10

BA'w 5

BB'r 6



EQUATORIAL SCALE 1: 77 000 000

PRECIPITATION EFFECTIVENESS

P-E INDEX

A-128+ WET

B-64-127-HUMID

C-32-63-SUBHUMID

D-16-31-SEMIARID

E-0-15-ARID

r-RAINFALL ADEQUATE AT ALL SEASONS

w-RAINFALL DEFICIENT IN WINTER

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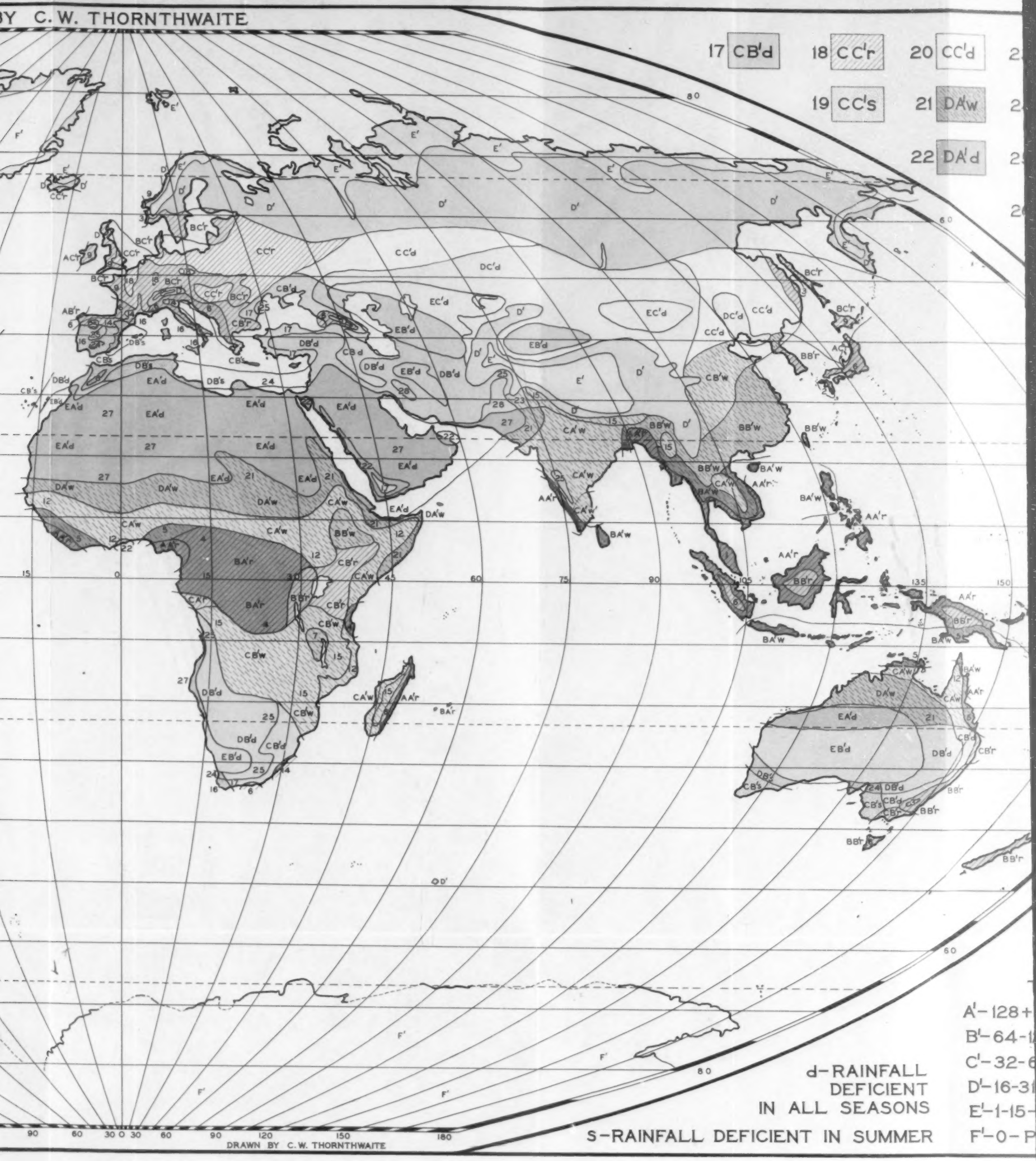
ATES OF THE EARTH

BY C. W. THORNTHWAITE



A'-128+

B'-64-1

C'-32-6

D'-16-3

E'-1-15-

F'-0-P

d-RAINFALL DEFICIENT IN ALL SEASONS

S-RAINFALL DEFICIENT IN SUMMER

CLIMATES OF THE EART

BY C. W. THORNTHWAITE

CA'r 11 CB'r 14 CB's 16

CA'w 12 CB'w 15

CA'd 13

r–RAINFALL ADEQUATE AT ALL SEASONS

w–RAINFALL DEFICIENT IN WINTER

DRAWN BY

EARTH

The Geographical Review, Vol. XXIII, No. 1, 1933, Pl. V

E

17 CB'd | 18 CC'r | 20 CC'd | 23 DB'w | 27 EA'd

19 CC's | 21 DA'w | 24 DB's | 28 EB'd

22 DA'd | 25 DB'd | 29 EC'd

26 DC'd | 30 D'

31 E'

32 F'

80 60 40 20 0

0 15 30 45 60 75 90 105 120 135 150 165 180

120 150 180

DRAWN BY C. W. THORNTHWAITE

d–RAINFALL DEFICIENT IN ALL SEASONS

S–RAINFALL DEFICIENT IN SUMMER

TEMPERATURE EFFICIENCY T–E INDEX

A'–128+–TROPICAL

B'–64–127–MESOTHERMAL

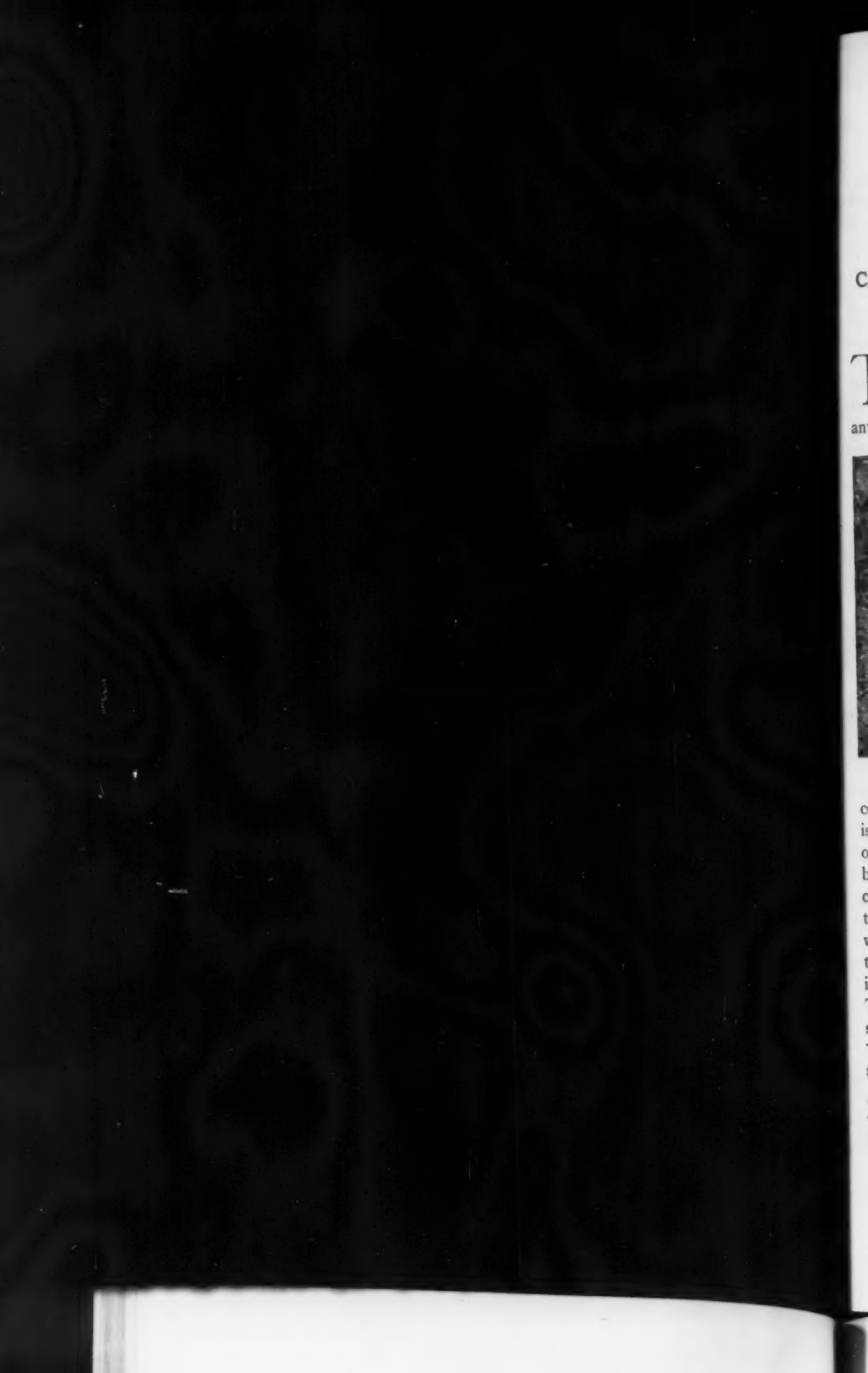
C'–32–63–MICROTHERMAL

D'–16–31–TAIGA

E'–1–15–TUNDRA

F'–0–PERPETUAL FROST

Lithographed by A. Hoen & Co. Baltimore



NOTES ON THE DEVELOPMENT OF THE CARTOGRAPHIC REPRESENTATION OF CITIES

Margaret Irene Fead

THE first known city maps are those from Mesopotamia. A crude and simple plan of Babylon, done on a clay tablet, is an attempt to show the areal spread of a city and is of great antiquity. Eckert dates it from about the middle of the seventh

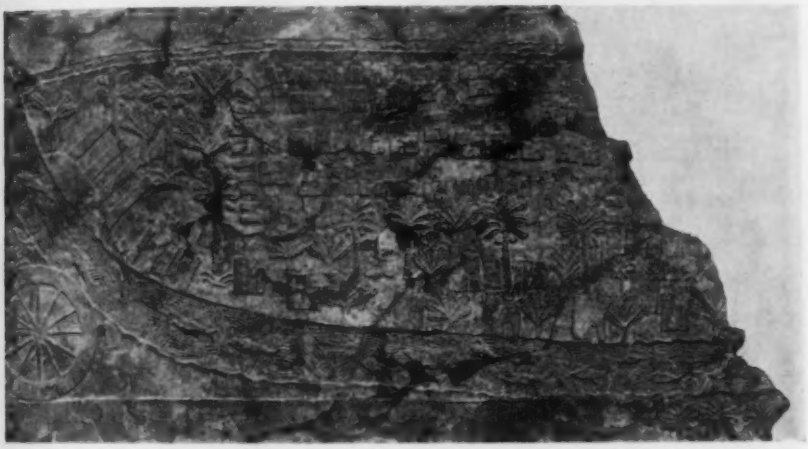


FIG. 1—The city of Madaktu from a photograph of the bas-relief in the British Museum.

century before Christ.[1] The Euphrates, represented by wavy lines, is mapped as flowing past the walls of the town. A plan of the city of Madaktu of 650 B.C. (not Susa or Shushan, as the city is called by Daly and Loftus), appearing on a slab of baked brick, is probably contemporaneous with the map of Babylon.[2] The bas-relief was made to adorn the walls of the palace of Ashurbanipal, king of Assyria, who reigned in 668–626 B.C. at Nineveh. Unfortunately a part of the slab showing the city has been destroyed. The part remaining is bordered by two rivers, and the ground plan of the city is distinct. The immediate town, surrounded by a turreted wall, is made up of square flat-roofed buildings, a few of which have turrets. Outside

[1] Max Eckert: Die Entwicklung der kartographischen Darstellung von Stadtlandschaften, *in* Siegfried Passarge: Stadtlandschaften der Erde, Hamburg, 1930, pp. 1–14; reference on p. 3.

[2] "Madaktu" according to Cyril John Gadd of the Department of Egyptian and Assyrian Antiquities, British Museum. See C. P. Daly: On the Early History of Cartography, or What We Know of Maps and Map-Making Before the Time of Mercator, *Journ. Amer. Geogr. Soc.*, Vol. II, 1879; pp. 1–40; A. H. Layard: Discoveries in the Ruins of Nineveh and Babylon, New York, 1853, p. 452; W. K. Loftus: Travels and Researches in Chaldaea and Susiana, New York, 1857, p. 336.

the walls of the town proper and bordering the river are representations of palm trees and of houses similar to those within the walls. One house stands under each tree. On the bank of the river appear two buildings, probably forts, one of which is raised on a mound.

Perspective and Horizontal Plans

City maps may be classified as perspective or horizontal. The perspective plan in addition to the areal spread of the city, which is the chief characteristic of the horizontal or ground plan, gives the height and depth. It is a hybrid of the ground plan and city view, or panorama; and the type varies according to the angle and elevation from which the maker pictured the city. The horizontal plan is the earlier type of city map. In the Capitoline Museum there is a fragmentary horizontal plan of Rome of 210 A.D., represented on a scale estimated by Oberhummer to be 1:250. It is executed so clearly and in such great detail that even the columns inside the buildings can be identified.[3]

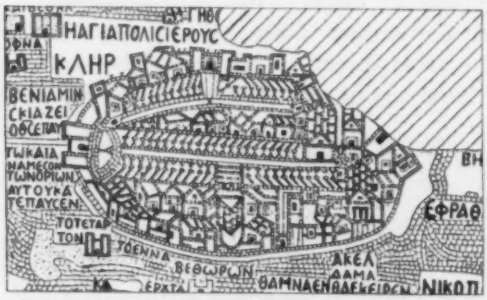


FIG. 2—Jerusalem on the Madeba map. Reproduction from the map in Adolf Jacoby: Das geographische Mosaik von Madaba (Studien über Christliche Denkmäler N. F. 3, Leipzig, 1905).

Some Early Maps of Jerusalem

The earliest known example of the perspective plan, dating from about 400 years later, is that of Jerusalem on the Madeba map. This mosaic map, rendered on a grand scale, was discovered in 1884 on the floor of a church in Madeba, Transjordania. It represents Palestine and parts of Egypt and Arabia before the Mohammedan conquest and was probably constructed between 578 and 608 A.D.[4] This is the earliest known example of a map in which east is at the top. Oberhummer[5] ascribes the orientation to geographical reasons, that is, the map is made to represent the area as it would appear to a trader from the sea. Others claim that the orientation had a religious significance: the map, which shows among other things the distribution of the tribes of Israel, was undoubtedly made for ecclesiastical

[3] Eugen Oberhummer: Der Stadtplan, seine Entwickelung und geographische Bedeutung, *Verhandl. XVI Deutschen Geographentages*, 1907, pp. 66–101; reference on p. 74.

[4] Date according to Peter Thomsen: Das Stadtbild Jerusalems auf der Mosaikkarte von Madeba, *Zeitschr. Deutschen Palästina-Vereins*, Vol. 52, 1929, pp. 149–174; reference on p. 171. Earlier authorities have placed the date as early as 500 A. D. Thomsen's paper is accompanied by a colored reproduction of the plan of Jerusalem.

[5] Oberhummer, *op. cit.*, p. 78.

purposes. In either case, this orientation became a tradition for almost a thousand years. The city of Jerusalem on the Madeba map is shown by a low perspective plan. A wall with towers surrounding the city is broken by three gates, the one opening to the north being the Damascus gate of today. From this gate the principal street, lined on both sides with roofed passageways, goes straight through the city. Buildings are easily distinguishable within the wall.

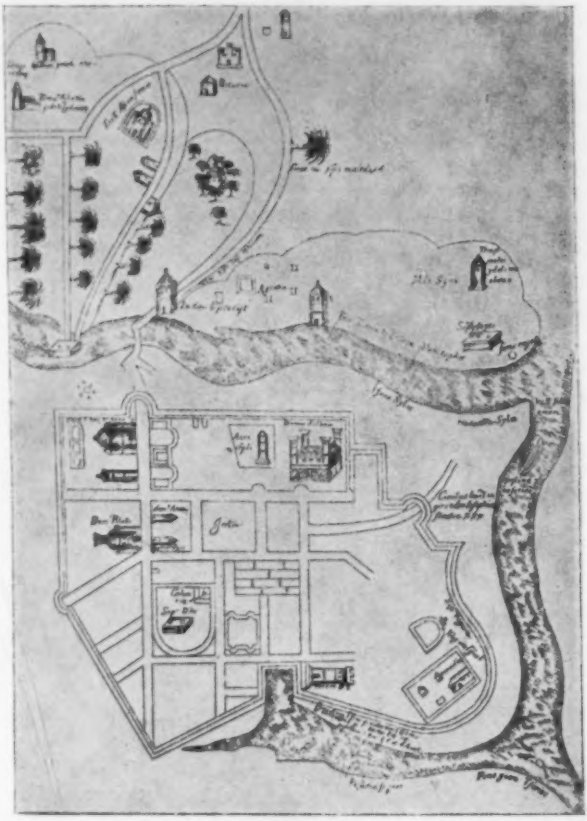


FIG. 3—Jerusalem after Marino Sanudo, ca. 1320 A. D.

More distinctly executed than the Madeba map is the high perspective plan of Jerusalem made about 670 A.D. by the Frankish pilgrim, Arculf, who gave an account of the Holy Land to Adamnan, abbot of Iona. Like the plan of Jerusalem on the Madeba it has the east at the top. The walls, flanked with towers, and the gates, carefully named, apparently consumed the interest of the earnest pilgrim, for within the gates there is nothing.

The period from the seventh century to the eleventh is one of scarcity in cartographic work as far as cities are concerned, and plans made during these centuries are known only through references to them in the literature of the time. Einhard,[6] a contemporary and favorite of Charlemagne, described, among other valuable possessions in the emperor's remarkable library, three silver tables on which maps were delineated. One of these, a round table on which Rome was drawn, was to be sent on his death to the cathedral at Ravenna; and a square table with a representation of Constantinople was to

[6] Einhardi vita Karoli imperatoris, edidit Alfred Holder, Freiburg, 1882.

go to the Basilica of St. Peter the Apostle at Rome. These tables, unknown today except through Einhard, probably suffered a fate similar to that of the map of the universe on the third table, which was broken into bits by Lothair, a son of Charlemagne, to pay his soldiers.

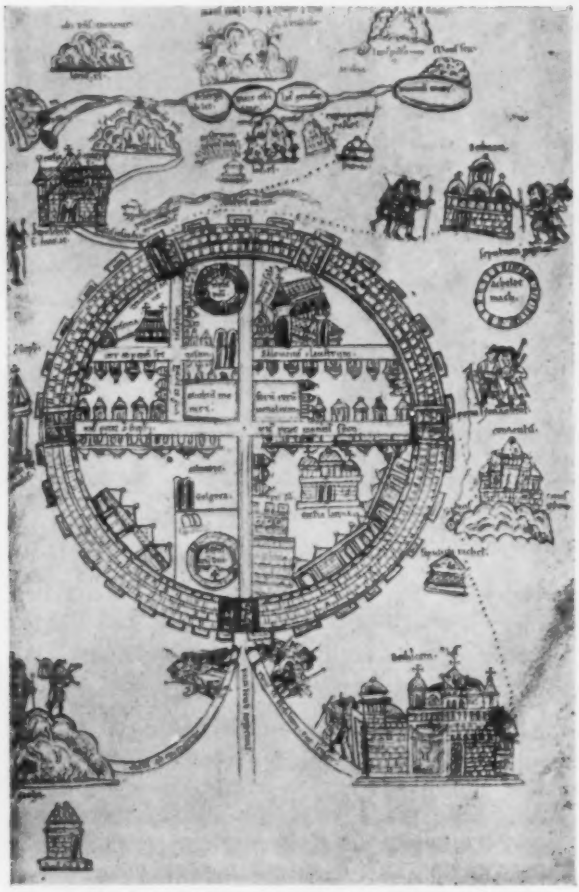


FIG. 4—The "Situs Hierusalem" of ca. 1100 A. D.

After this lapse in the record the horizontal plan known as the "Situs Hierusalem" of ca. 1100 A.D. makes its appearance. The Holy City is represented less truly than in the perspective plan on the Madeba mosaic. It is given a circular form, and the street pattern is highly schematic. The city is surrounded by what appears to be a strongly built wall. The several copies of the plan differ in the information around the map of the city proper. In the Brussels copy the whole course of the Jordan is shown. In the Montpellier copy the earlier rounded form of Jerusalem is made square.

In contrast to the "Situs Hierusalem" is the ground plan of Jerusalem usually attributed to Marino Sanudo, who wrote "Liber Secretorum Fidelium Crucis"[7] about 1320 A.D., and was supposedly the designer of plans of Jerusalem, Antioch, and Acre.[8] A comparison of Figures 3 and 4 shows the greater realism of Sanudo's plan.

[7] The text of "Liber Secretorum Fidelium Crucis" of Marino Sanudo the Elder will be found in Jacques Bongars: Gesta Dei per Francos, 2 vols., Hanover, 1611.

[8] Sanudo's work corresponds with that of Pietro Vesconte, who was a contemporary, and it is not known whether or not one copied or the two collaborated. See C. R. Beazley: The Dawn of Modern Geography, Oxford, 1906, Vol. 3, p. 521; Oberhummer; *op. cit.*, p. 82; Konrad Kretschmer: Marino Sanudo der Ältere und die Karten des Petrus Vesconte, *Zeitschr. Gesell. für Erdkunde zu Berlin*, Vol. 26, 1891, pp. 352–370.

Bondelmonti Map of Constantinople

Constantinople is excellently depicted in Bondelmonti's manuscript "De Insulis Cycladis" of 1440. Here will be found a perspective plan that realistically portrays the city and shows marked improvement over earlier city maps. St. Sophia, the hippodrome, Justinian's palace, and many other buildings and the towers, turrets, and walls are all carefully shown. The description of the city in the text and the map drawn by the careful observer compare very favorably. There is also a striking perspective plan of Constantinople, together with similar plans of nine other cities, in a magnificent manuscript of Jacopo d'Angiolo's Latin translation of the "Geography" of Ptolemy now preserved in Paris.[9]

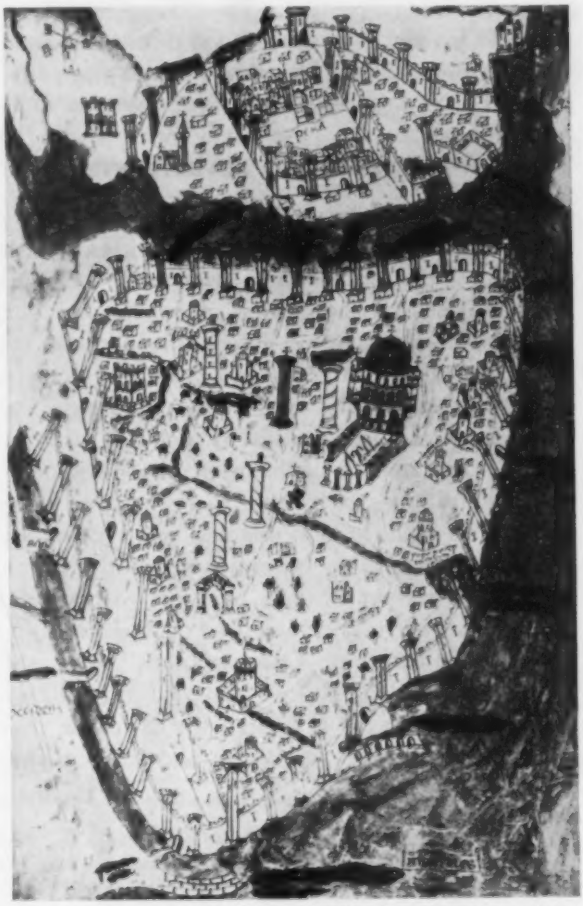


Fig. 5—Constantinople after Bondelmonti, 1440. An original manuscript of Bondelmonti's "De Insulis Cycladis" is in the library of the University of Michigan.

City Views

The "Liber Chronicarum," or so-called Nuremberg Chronicle of Hartmann Schedel, in the edition printed at Nuremberg, 1493, contains city views. The city view, although not a map in the strict sense but merely a panoramic view of the city, was popular in atlases in the late fifteenth and in the sixteenth century. In the Chronicle 22 representative cuts of a fine group of rather impressive buildings

[9] Bibliothèque Nationale, Latin MS. 4802; see reproduction "Géographie de Ptolémée, traduction latine de Jacopo d'Angiolo de Florence," Bibliothèque Nationale, Dépt. des Manuscrits, Paris, n.d.

are used for 69 cities and countries, while 26 larger cuts, some from sketches, portray cities and are not repeated.[10] One woodcut appears four times, representing Alexandria, Athens, Pavia, and an unnamed city. For the larger cities like Constantinople and Rome the views verge on the perspective. The "Supplementum Supplementi Chronicarum" by Bergomensis of 1503 contains many views of towns, of which a few are real likenesses. In Wyngaerde's "View of London" of 1550 a true representation in panorama of the city is attempted.

Sixteenth and Seventeenth Century Maps

Not till the late sixteenth and the seventeenth century did the ground and perspective plans of cities become more accurate in execution. In Sebastian Münster's "Cosmographia," of which many editions appeared during the latter half of the sixteenth century, the perspective plan enjoyed considerable popularity. The map showing Paris is rather crude, and the street pattern is ill defined. The structure of the city is represented by closely grouped one-story houses, relieved occasionally by a church with a characteristic steeple. The east is at the top of the map, and the Seine is represented by wavy lines, reminding one of the early map of Babylon. For the most part the city plan is monotonous: one type of house is shown throughout, and outstanding buildings are not executed in a manner comparable to that in Braun's perspective plan of the same period. A much more carefully drawn plan of Paris appears in the French translation of Münster's "Cosmographia" as revised and enlarged by François de Belleforest and others and published in Paris in 1575.

One of the most extensive works of the many appearing in this period[11] was by Georges Braun and Francis Hogenberg, the massive

[10] Sydney C. Cockerell, edit.: Some German Woodcuts of the Fifteenth Century, Hammersmith, 1897.

[11] "Civitates Orbis Terrarum" was published in Cologne and is dated 1572–1618. The German edition, "Beschreibung und Contrafactur der vornehmensten Stadte der Welt," was also published in Cologne in 1574, while the French edition, entitled "Le Grand theatre des differentes citès du monde," was published in Brussels in 1572.

The following is a list, in addition to those cited in the text above, of some of the principal atlases of this period containing city maps, with the number of maps appearing in each atlas:

P. d'Avity: Newe Archontologia cosmica. . . . Frankfurt on the Main, 1646. 34 maps.

J. Blaeu: Theatrum civitatum et admirandorum Italiae. . . . Amsterdam, 1663. Vol. 1, 38 maps; Vol. 2, 1 map.

J. Blaeu: Toonneel der Steden van de Vereenighde Nederlanden. . . . Amsterdam, 1649. Vol. 1, 89 maps; Vol. 2, 1 map.

M. V. Coronelli: Collection des vues des villes et des plans dans les Pays-Bas. Venice, 1697. 10 maps.

F. De Wit: Theatrum praecipuarum totius Europae urbium. . . . Amsterdam, [1695?]. 101 maps.

N. de Fer: Les forces de l'Europe ou description des principales villes. . . . Paris, 1696–1697. 77 maps.

M.-Z. Boxhorn, Illustriorum . . . urbium tabulae (published by Jansson). Amsterdam, [1632? ff.].

A. Lafrery: Geografia tavole moderne di geografia. . . . Rome, [1575?]. 23 maps.

N. Tassin: Les plans et profils de toutes les principales villes de France. Paris, 1634. Vol. 1, 92 maps; Vol. 2, 94 maps.

"Civitates Orbis Terrarum," designed to accompany the "Theatrum Orbis Terrarum" by Ortelius. This six-volume work was the greatest undertaking that has ever been attempted in its field. It contains no less than 540 maps and views of cities. Several editions came out in German, French, and Latin. The atlas enjoyed wide popularity, rapidly becoming a classic, and the maps were frequently reproduced in other publications of the period. In it the maps of Paris and London are outstanding among the perspective plans.

The map of Paris, which dates from 1530, is oriented with the east at the top, while that of London has north at the top. The maps of London as early as the sixteenth century follow what has become the more conventional orientation, an orientation generally believed to have been fostered by the use of the compass, which navigators had employed in constructing Portolan charts since the thirteenth century. On the other hand, the maps of Paris remained with the east at the top until the seventeenth century. There is little uniformity in the workmanship of the "Civitates Orbis Terrarum." The orientation varies in the maps, and there are found city views, for example Lisbon, and perspective plans, for example Paris. The map of Paris is rather carefully done. Notre Dame and other churches and government buildings are shown with representations of residences filling up the rest of the city blocks. The map is truly a work of art with an elaborate cartouche in the upper left-hand corner and with three figures attired in the fashions of the time in the lower left-hand corner. From these three figures the map has been designated as "aux trois personnages."[12] Much larger and more detailed than either this plan or that of Sebastian Münster, but not so widely copied, is the great plan dating from about 1551 made by Olivier Truschet and Germain Hoyau.[13] A copy of this plan was discovered in Basel about the middle of the nineteenth century.

The map of London by John Norden in his "Speculum Britanniae" of 1593[14] expresses a new interest in the thought of the people. The border is made up of the coats of arms of the various London guilds—grocers, goldsmiths, and the like.[15] It is not known whether the guilds subscribed to the making of the map, as was often their custom in the case of books, but in any event the coats of arms indicate the beginning of an interest in commercial activity. An important modern trend in city map making is to stress the location of industries and commercial enterprises and to designate their distribution by

[12] *Ann. de Géogr.*, Vol. 40, 1931, opp. p. 480.

[13] Reproduced in 1908 by the firm of A. Taride, Paris, in their series of reproductions of early maps of Paris dating from about 1530 to 1842.

[14] This map is reproduced in "Maps of Old London," edited by G. E. Mitton (Adam and Charles Black, London, 1908), a volume containing 9 reproductions of maps and views of London dating between 1543 and 1745.

[15] Coats of arms of guilds are found on the map "An Exact Delineation of the Cities of London and Westminster," by Faithorne and Newcourt of 1658.

FIG. 6—The Île de la Cité from the map of Paris in Sebastian Münster's "Cosmographia," edition of 1598.

FIG. 7—The Île de la Cité from Braun's map of Paris ("aux trois personnages") in 1530.

different colors or symbols. No such attempt appears to have been made in the period under consideration, although certain guilds at this time were confined to particular streets in Paris and London, as many of the modern names bear witness.

By contrast with the maps preceding them, Nicolay's horizontal plan of Paris in 1609 and Merian's perspective plan of Paris in 1615 are arresting in detail. Nicolay's map is splendidly executed. Names of streets and of buildings like Notre Dame are inscribed in the exact location, and there is very little of the conventional. In "Le Plan de la Ville . . . de Paris" of 1615 by Merian, the city spreads out before us in its diminutive perfection. Both plans are drawn with the east at the top.

Beginnings of Conventionalization

After this period of great atlases and extensive representations of cities, perspective plans appear modestly around the borders of the maps of greater areas. The map of the New World entitled "Americae Nova Tabula," published in various editions of William Blaeu's great atlas dated 1635–1654, shows Cuzco and Mexico City[16] in perspective. Insets of important cities on maps of greater areas are occasionally found.

The horizontal plan continued to retain its popularity but with marked changes. In contrast to the photographic character of Nicolay's plan is a map of Paris by Bullet and Blondel, dated 1670–1676. It marks a stepping stone between the older pictorial map and the later conventionalized one. Except for the important governmental and ecclesiastical buildings, which are pictorially represented, the city blocks are stippled. Symbolic representation on city maps is definitely creeping in.[17] Paris in relation to its environs is shown on an inset with the north at the top. Jouvin de Rochefort's map of Paris of 1675[18] and that of N. de Fer of 1697 are especially notable for the fact that they are among the first large plans of the French capital in which the conventional orientation is employed.[19]

Cartographic technique improved progressively during the seventeenth and eighteenth centuries. With the rise of strongly centralized European monarchies the need was felt for detailed topographic maps for military purposes.[20] The "benevolent despots" of the period

[16] Compare plan and perspective view of Mexico City in Johannes Vingboons' atlas *ca.* 1665, reproduced in F. C. Wieder: Monumenta Cartographica, The Hague, 1932, Vol. 4.

[17] Another example of this change from the pictorial to the conventionally represented city map is Robert Morden and Philip Lea's "A Prospect of London and Westminster" of 1682.

[18] Reproduced in the Taride series referred to above, note 13.

[19] Léonard Gaultier's panoramic view of Paris (1607) shows north at the top (*Geogr. Rev.*, Vol. 13, 1923, p. 356).

[20] See J. K. Wright: Early Topographical Maps: Their Geographical and Historical Value as Illustrated by the Maps of the Harrison Collection of the American Geographical Society, *Amer. Geogr. Soc. Library Ser. No. 3*, 1924.

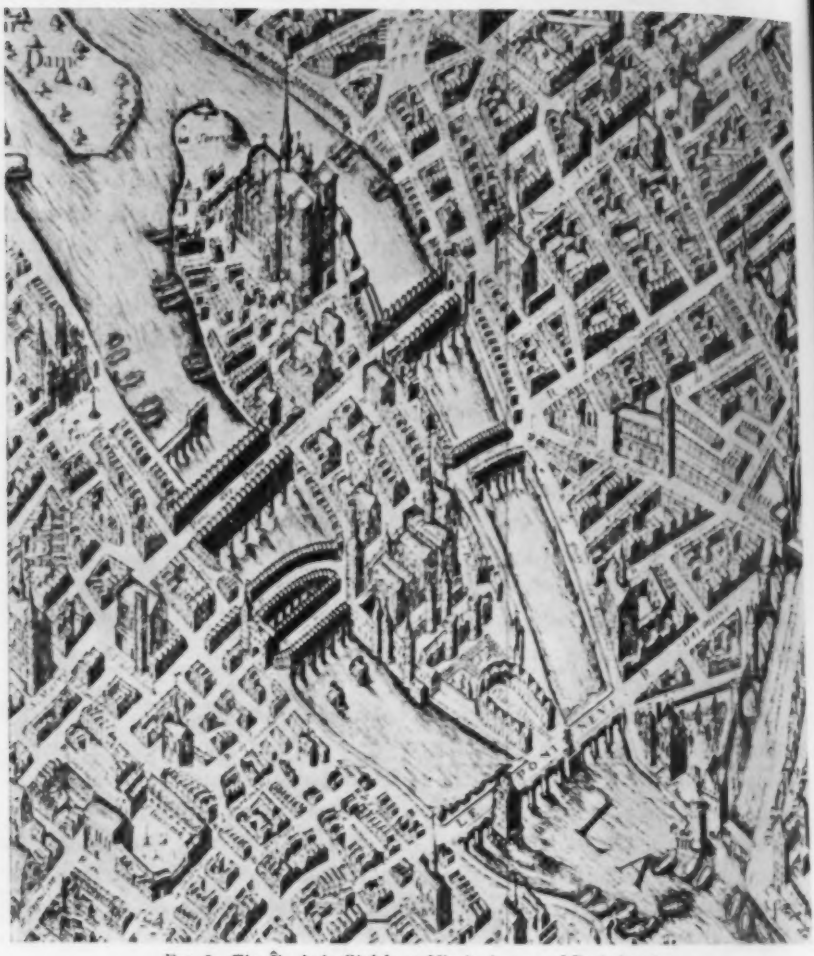


FIG. 8—The Île de la Cité from Nicolay's map of Paris in 1609.

were also interested in promoting investigations in pure science. A great series of surveys was undertaken to determine the size and shape of the earth, in the course of which triangulation was first used on a large scale. The development of better instruments and more refined methods lent precision to the whole art of cartography. Map making tended definitely to leave the hands of the illustrator, the navigator, and the ecclesiastical scholar and to pass into those of the cartographic specialist. This movement, however, was somewhat delayed in the field of city plans. Cities had been mapped with such pleasing and on the whole satisfactory results by the older and simpler methods employed in the great period of atlas making of the sixteenth and seventeenth centuries that there was no pressing demand for accurate and up-to-date plans. During the eighteenth century the number of city atlases published and the number of city representa-

FIG. 9—The Île de la Cité from Merian's map of Paris in 1615.

tions contained in the atlases decreased somewhat,[21] although the period 1730–1750 was marked by the appearance of a considerable number of large plans.[22] A few city maps appeared as insets on rep-

[21] Compare this list of atlases of the period with those in note 11.

J. Andrews: A Collection of the Most Capital Cities of Every Empire. . . . London, 1772. 42 maps.

J. Blaeu: Nouveau théâtre d'Italie. . . . Amsterdam, 1704. Vol. 1, 42 maps; Vol. 2, 39 maps; Vol. 3, 14 maps; Vol. 4, 1 map.

J. Blaeu: Nouveau théâtre du Piémont. . . . The Hague, 1725. Vol. 1, 3 maps; Vol. 1, Part II, 24 maps; Vol. 2, Part I, 14 maps; Vol. 2, Part II, 31 maps.

G. Bodenehr: Dritter Theil des Tractats Genandt Europens. . . . Augsburg, 1737. 3 maps.

H. Du Sauzet: Profils ou vues des principales villes. . . . Amsterdam, 1739. 77 maps.

Homann Heirs: Stadt-Atlas. . . . 1762. 50 maps.

J. Rocque and J. N. Bellin: Recueil des villes, ports d'Angleterre. . . . Paris, 1766. 20 maps.

P. Schenk: Hecatompolis. . . . Amsterdam, 1702. Contains only views.

[22] Notably Turgot's plan of Paris, completed in 1739 (reproduced in the Taride series, cited above, note 13), and John Rocque's Map of London, 1741–1745 (reproduced in "Maps of Old London"). See also Max Eckert: "Die Kartenwissenschaft," Berlin and Leipzig, Vol. 1, 1921, p. 378.

resentations of greater areas, and occasionally earlier seventeenth century types were carefully elaborated. For the most part perspective plans were less frequent and the horizontal plan grew more accurate. With the coming of the industrial economy of the nineteenth century, however, there was a rapid development of cities. Interest was again awakened in the city map, and an acute need for it arose. The need, combined with a better cartographic technique, favored the use of the horizontal plan. A new factor—the popular rise of photography—entered toward the middle of the nineteenth century. Inasmuch as photographs give a pictorial representation of the city from an angle, the passing of the perspective plan from the hands of the cartographer into those of the photographer was seen.

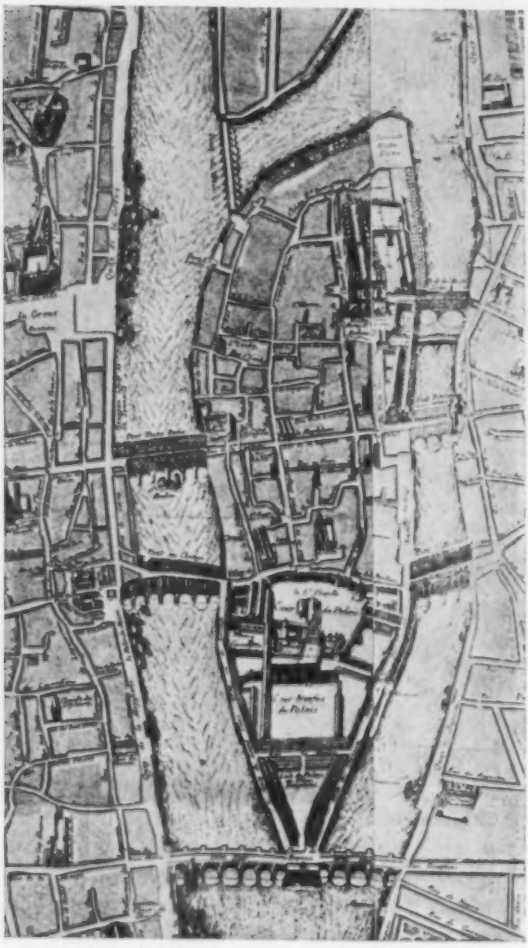


FIG. 10—The Île de la Cité from Bullet and Blondel's map of Paris in 1676.

THE GROUND PLAN IN THE NINETEENTH CENTURY

The ground plan, however, held its own. From the period when the completely conventional plan first appeared, such as Robert de Vaugondy's map of Paris (1760), the city maps continued much the same for about a century and a half.[23] In the nineteenth century great numbers of county and city atlases were produced in the United States. The evolution of city plans of Manhattan Island, New York

[23] "Le plan de la ville et des faubourgs de Paris divisée en vingt quartiers" by Gilles Robert de Vaugondy, 1760, appears in "Tablettes parisiennes qui contiennent le plan de la ville et des faubourgs de Paris divisée en vingt quartiers, avec une dissertation sur les aggrandissements" . . . Paris, 1760. In Library of Congress.

City, may be traced in the magnificent publication of I. N. Phelps Stokes, "The Iconography of Manhattan Island."[24] The map of Pontiac, Michigan, in Beers's "Atlas of Oakland County, Michigan" of 1872, may be cited as an example of the type of city map popular in the United States in the later nineteenth century. The city is drawn on a scale of one inch to 300 feet. This or approximately this

FIG. 11—The Île de la Cité from Jouvin de Rochefort's map of Paris in 1675, one of the first maps of the city employing the conventional orientation of north at the top.

scale was widely used for mapping the principal city of each county in the county atlases. Political divisions and the location of public and commercial buildings and property holdings are the dominant characteristics. The detail to which city mapping was carried in the United States may be seen by noting the "Atlas of Philadelphia" by Griffith Morgan Hopkins of 1884–1887. The plates are on pages 13 inches by 20 inches, and the city is drawn on a scale of one inch to 100 feet.[25] As field technique developed there went hand in hand a greater accuracy in mapping and a further conventionalization of signs.

The making of ground plans is now passing from the field surveyor to the aerial photographer. Vertical photography from the air is proving satisfactory because the areas of cities are small enough to

[24] I. N. Phelps Stokes: The Iconography of Manhattan Island, 6 vols., New York, 1915–1928. Reproductions of many plans and panoramic views of American cities in the seventeenth, eighteenth and early nineteenth centuries will be found in I. N. Phelps Stokes and Daniel C. Haskell: American Historical Prints: Early Views of American Cities, etc. from the Phelps Stokes and Other Collections, New York, 1932 (see *Geogr. Rev.*, Vol. 22, 1932, pp. 702–703).

[25] County and city atlases of the United States were published by Beers, Titus, Geil and Jones, Everts and Stewart, and Stewart and Hopkins. For detailed lists see L. C. Karpinski: Bibliography of the Printed Maps of Michigan 1804–1880, Lansing, Mich., 1931; P. L. Phillips: A List of Geographical Atlases in the Library of Congress, Washington, 1909.

be photographed in detail without great cost, and the work can be done more easily and accurately than by laborious surveys in the field.

Morphological Ground Plans

Two outgrowths of the horizontal plan are the morphological and the functional ground plans. It is not known exactly how the morphological ground plan originated, but this type of map dealing with the form and structure of the city is of growing importance in quantitative studies of city geography. Probably the first morphological ground plan was a map showing types of buildings. Such a map was made for London by Thomas Leverton as early as 1785; it depicts the composition of building material in the central part of the city.[26] In 1850 sheets were available for small towns in the United States showing the kinds of buildings. On Perris' map of New York City of 1852, which discloses each lot and building, the types of buildings are represented by different colors in the first four wards. The Sanborn insurance atlases of most of the cities of the United States contain fine examples of the morphological ground plan. These city maps are constructed on a scale of one inch to 50 feet. Although they cover such congested areas as the commercial, manufacturing, and poorer residential districts only, a fair idea of the entire city may be gathered from the combination of the key map and the various sheets. Important buildings and their form, structure, and composition are noted. The number of stories is designated by Arabic numerals, and the type of material used in construction is shown by colors; yellow signifying frame; red, brick; blue, stone; gray, iron; brown, fireproof. The physical aspects of the city are thus carefully and minutely represented. As far as the United States is concerned the history of the morphological ground plan has been that of the fire insurance map which appeared about 1850.

Functional Ground Plans

Rather recently the ground plan has been used in portraying the functional areas of the city. The functional plan has a wider appeal than the morphological, but, as yet it is little used by the layman. Probably one of the earliest functional ground plans was that by Kröcher of 1913 showing Stettin.[27] This was followed by Geisler's map of Danzig of 1918 showing the uses of buildings within the core of the city.[28] Other studies followed these, accompanied by maps prepared in greater detail. Richard Pohle in a study of Riga

[26] R. P. Getty: Insurance Surveying and Map Making, *Cassier's Mag.*, Vol. 39, 1910–11, pp. 19–25.

[27] Hans Kröcher: Stettin: Ein Beitrag zur modernen Stadtgeographie, Inaug. Diss., Greifswald, 1913.

[28] Walter Geisler: Danzig, ein siedlungsgeographischer Versuch, Inaug. Diss., Halle, 1918.

gives a crude type of functional plan. The built-up part of the city is mapped, and the railroad holdings, parks and cemeteries, pine woodland, and warehouses are differentiated.[29] Sten De Geer in an article on Stockholm shows the functional areas of the core of the city. The various functional districts given on the map of Stockholm are the wholesale and retail business district; the financial district; the newspaper center; the national administrative district; the market centers; the medical centers; and the retail furniture center.[30] Another advance in presenting functional areas appears on the maps accompanying the study by John B. Leighly on "The Towns of Mälardalen in Sweden," published in 1928.[31] The towns of Eskilstuna and Vasteras, Sweden, are mapped for 1926. On these maps the functional areas distinguished are: the "closed" buildings area; the business district; the industrial area; the "free" built industrial area; the poorer "open" dwelling areas; the better "open" dwelling areas; and the uniform "open" dwelling areas. Public institutions with grounds, planted parks, cemeteries, unimproved parks, and athletic fields are mapped. The maps of Rio de Janeiro and São Paulo appearing in the April number of the *Geographical Review* are examples of the functional city map.[32]

For other purposes real estate promoters and chambers of commerce of the various cities are sponsoring the compilation of functional plans. These plans, however, are still in their infancy. Aerial photography will unquestionably render notable services in their future development.

A word might also be said here of the "urban profile" which has some elements in common with the city panoramas of the fifteenth and sixteenth centuries. Van Cleef has exhibited "silhouettes of urban centers in Ohio"; Hall's profiles of Nara City, Japan, also incorporate morphological and functional features; while Parkins has given details by city streets.[33]

Modern Trends in City Maps

The city of today is served by an extraordinarily complex mechanism of streets, rapid transit lines, water and gas mains, sewers, electric power transmission cables, telegraph and telephone wires.

[29] Richard Pohle: Riga, *Meereskunde*, Vol. 13, No. 8, Berlin, 1920.

[30] Sten de Geer: Greater Stockholm . . . , *Geogr. Rev.*, Vol. 13, 1923, pp. 497–506.

[31] John B. Leighly: The Towns of Mälardalen in Sweden: A Study in Urban Morphology, *Univ. of California Publs. in Geogr.*, Vol. 3, No. 1, Berkeley, 1928, pp. 1–134.

[32] Maps on the scale of 1 : 60,000 in Preston E. James: Rio de Janeiro and São Paulo, *Geogr. Rev.*, Vol. 23, 1933, pp. 271–298. See also the same: Vicksburg, *ibid.*, Vol. 21, 1931, pp. 234–243; Clifford M. Zierer: Scranton as an Urban Community, *ibid.*, Vol. 17, 1927, pp. 415–428.

[33] Eugene Van Cleef: The Urban Profile, *Annals Assn. of Amer. Geogrs.*, Vol. 22, 1932, pp. 237–241. Robert Burnett Hall: The Yamato Basin, Japan, *ibid.*, pp. 243–292, with separate plate of profiles. A. E. Parkins: Profiles of the Retail Business Section of Nashville, Tenn., and Their Interpretation, *ibid.*, Vol. 20, 1930, pp. 164–175.

For all of these, engineers require special types of ground plan. City planners are developing new methods in the cartographic representation of urban land utilization and of the distribution and composition of city population, as well as of traffic, business enterprise, and the probable future changes in these elements. Sociologists and social workers are finding clues to the solution of many problems in the accurate plotting on ground plans of racial, linguistic, and religious groups, and of the conditions of housing, poverty, crime, and disease. It has been found that for many studies the average ward in the American city is too large and too shifting to serve as a satisfactory unit. The U. S. Census Bureau has undertaken the tabulation of data by permanent census tracts, much smaller than wards, and in this way provides material from which far more refined demographic maps can be compiled than have hitherto been possible. There are thus becoming available for the use of students of cities not only maps and plans of types undreamed of in earlier days but material from which wholly new types of maps may be developed. City maps have evolved from the ornate to the simple, from the pictorial to the conventional, and from the artistic to the scientific; but like all maps "they represent the deposit of the geographic knowledge of their times."[34]

[34] Max Eckert: On the Nature of Maps and Map Logic, *Bull. Amer. Geogr. Soc.*, Vol. 40, 1908, pp. 344–351.

IRRIGATION IN THE LOWER RIO GRANDE VALLEY OF TEXAS

Edwin J. Foscue

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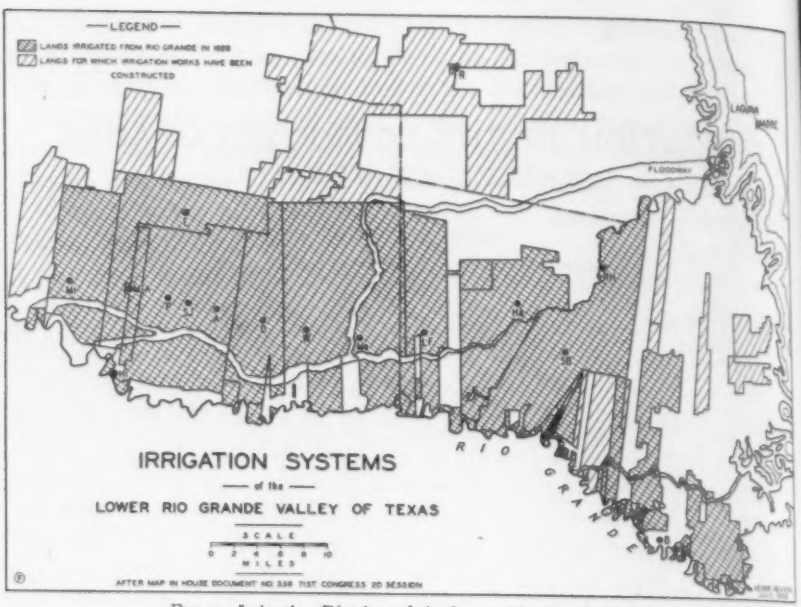
IRRIGATION on the Lower Rio Grande Valley of Texas has assumed importance only in the last thirty years,[1] but growth has been steady and "brush" pasture has been converted into citrus orchards, truck farms, and cotton fields to the extent of nearly 400,000 acres. A distinguishing feature of the system, which is quite unlike the government or corporation project dependent on a large storage reservoir, is the number of individual irrigation projects and the haphazard manner in which they have developed. Within the area there are 85 separate and distinct districts (Fig. 1). The acreage of the 11 larger projects is shown in Table I. The others range in size from 6000 acres down to only 30 acres. These either have their own small pumping plants or buy their water from the larger units. The 11 larger units are entirely independent. Each has its own pumping plant on the river and possibly one or two "lift" pumping plants to raise the water to the bench lands; each has its own main and lateral canals; and, under the supervision of the State Board of Water Engineers, each district makes its own rules and regulations for its water users. If all these projects could be organized into a major one, with its own storage dam and high-level canal to run back from the river on the outer margin of the irrigated area, a great saving would be effected. Such a consolidation is, however, dependent upon a treaty with Mexico to permit the building of a dam and reservoir.

In addition to the area now being irrigated several large tracts are waiting for ditches to be dug and water obtained from the river. Most of the proposed districts will be required to use only the flood waters of the Rio Grande and will not be allowed to divert water directly from the stream during normal stages.

Recent Improvements

The canals of the older districts are large earthen ditches that suffer a heavy loss of water through evaporation and seepage. Seepage is particularly unfortunate in that it causes not only loss of valuable

[1] Edwin J. Foscue: Land Utilization in the Lower Rio Grande Valley of Texas, *Econ. Geogr.*, Vol. 8, 1932, pp. 1–11; *idem:* The Natural Vegetation of the Lower Rio Grande Valley of Texas, *Field and Laboratory* (Contribs. from the Sci. Depts. of Southern Methodist University), Vol. 1, 1932, pp. 25–30.


— LEGEND —
LANDS IRRIGATED FROM RIO GRANDE IN 1909
LANDS FOR WHICH IRRIGATION WORKS HAVE BEEN CONSTRUCTED
IRRIGATION SYSTEMS
— of the —
LOWER RIO GRANDE VALLEY OF TEXAS
SCALE
0 2 4 6 8 10
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RIO GRANDE
LAGUNA MADRE
FLOODWAY

FIG. 1—Irrigation Districts of the Lower Rio Grande Valley.

IRRIGATION SYSTEM	ACREAGE IRRIGABLE	NOW CULTIVATED
1. El Jardine	20,682	15,000
2. Los Fresnos	16,262	14,100
3. San Benito	55,341	41,600
4. Harlingen	38,108	33,000
5. La Feria	26,537	23,900
6. Mercedes	69,000	55,000
7. Donna	35,800	32,500
8. San Juan	59,500	55,000
9. McAllen	7,290	7,000
10. Edinburg	31,500	27,500
11. Mission	28,000	26,000
Total	388,020	330,600

water but also waterlogging and consequent alkalization of land on both sides of the canal. Conditions in the delta are particularly favorable for alkali formation, but fortunately comparatively little alkali has appeared as yet on the good land of the valley, and tile drains are being installed.

The newer projects are lining their main canals with concrete. A much smaller canal is needed to carry the same amount of water to the land, and flooding is prevented. Some of the newer systems pipe the water to the land by underground conduits, thereby wholly eliminating the loss from evaporation. However, underground con-

duits are at present used only on the lateral canals and not on the mains. The pumping plan for each of the larger systems consists of a large intake pump which draws the water out of the river and pours it into the main canal. In the case of each of the projects west of the Harlingen system, a second pumping station raises the water to the first terrace above the river, the Beaumont, or Mission, terrace. On the westernmost projects a third lift pump raises the water up to the second level, the Reynosa upland.[2]

Flood prevention is another matter that has received attention. Floodways have been built and the dangers materially reduced. The unprecedented high water accompanying the Rio Grande flood of September, 1932, tested the floodways to the utmost, but aside from several minor breaks in the protecting levees no great damage was done to the lands of the valley.

International Aspects

The greatest need of the lands of the Lower Rio Grande Valley of Texas today is the control and storage, by reservoirs, of the flood waters of the stream. But the Rio Grande is here an international stream. The Treaty of Guadalupe Hidalgo, 1848, established the international boundary between the United States and Mexico as follows:[3]

> The boundary line between the two Republics shall commence in the Gulf of Mexico, three leagues from land, opposite the mouth of the Rio Grande, otherwise called Rio Bravo del Norte, or opposite the mouth of its deepest branch, if it should have more than one branch emptying directly into the sea; from thence up the middle of that river, following the deepest channel, where it has more than one, to the point where it strikes the southern boundary of New Mexico . . .

After the Gadsden Purchase a second treaty concluded in the City of Mexico, 1853, revised the boundary line west of the Rio Grande but made no change in the boundary along the river. All subsequent treaties concluded between the two countries, in 1882, 1884, 1889, and 1905, recognized the original boundary of the Rio Grande as set forth in the treaty of 1848.[4]

At the time of the Treaty of Guadalupe Hidalgo the Rio Grande found its chief use in transportation. Steamboat traffic reached its highest development in the period between 1848 and 1870, after which it declined until it terminated at the opening of the present century. It is not surprising then that part of Article 7 of the original treaty of 1848 should read:[5]

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[2] On the physiographic subdivisions of the Lower Rio Grande see the author's "Physiography of Lower Rio Grande Valley," *Pan-American Geologist*, Vol. 57, 1932, pp. 263-267.

[3] International Boundary Commission, United States and Mexico: Treaties, Joint Rules . . . . Dept. of State, Washington, 1925, p. 3.

[4] *Ibid.*, pp. 6-19.

[5] *Ibid.*, p. 4.

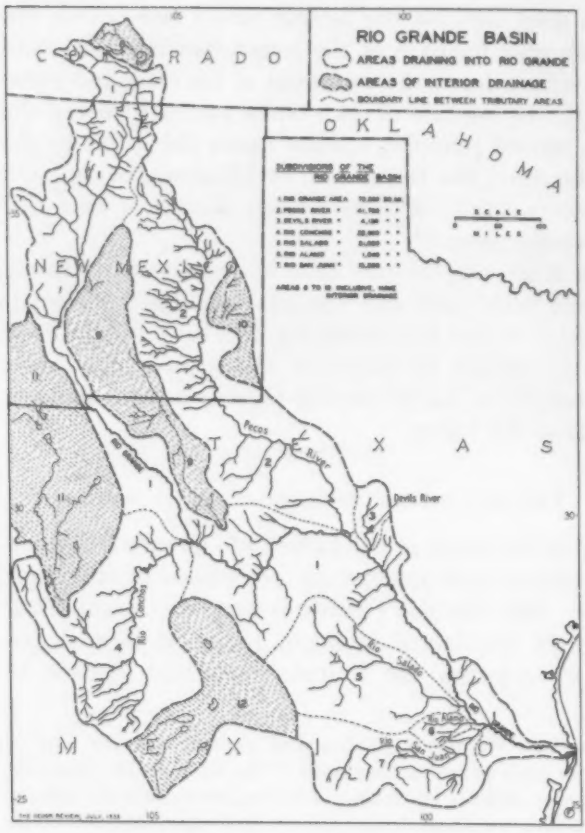

FIG. 2—The drainage basin of the Rio Grande. The Rio Grande proper from its source to the head of the delta drains approximately 72,200 square miles. The drainage basins of the tributaries total 105,000 square miles. In addition to this area a large basin or bolson lying between the Rio Grande and the Pecos River, in Texas and New Mexico, has interior drainage and contributes no water to the system. Three other bolsons lie respectively on the west of the Rio Grande in New Mexico, on the east of the Pecos River in New Mexico, and on the southwest of the Rio Grande in Mexico. If these non-producing districts were added to the area of the drainage basin proper, the total would comprise well over 200,000 square miles.

. . . the part of the Rio Bravo del Norte [Rio Grande] lying below the southern boundary of New Mexico, being . . . divided in the middle between the two Republics, the navigation . . . shall be free and common to the vessels and citizens of both countries; and neither shall, without the consent of the other, construct any work that may impede or interrupt, in whole or in part, the exercise of this right: not even for the purpose of favoring new methods of navigation.

This article is still in effect between the two countries, although the Rio Grande, which even at the height of the steamboat period was never navigable for more than one hundred miles from its mouth, has not been so used for more than thirty years, or since the introduction of modern transportation into the region. Use of the Rio Grande has changed from navigation to irrigation. The latter diverts the water permanently and thus forms a source of graver international problems than navigation has ever initiated.

The water that reaches the Lower Rio Grande Valley through the river comes largely from the tributaries, the Pecos and Devils rivers on the Texan side, and the Conchos, Salado, and San Juan rivers on the Mexican side (Fig. 2). The areas of the drainage basin are about equal on the two sides, but the American side lies in a region of very

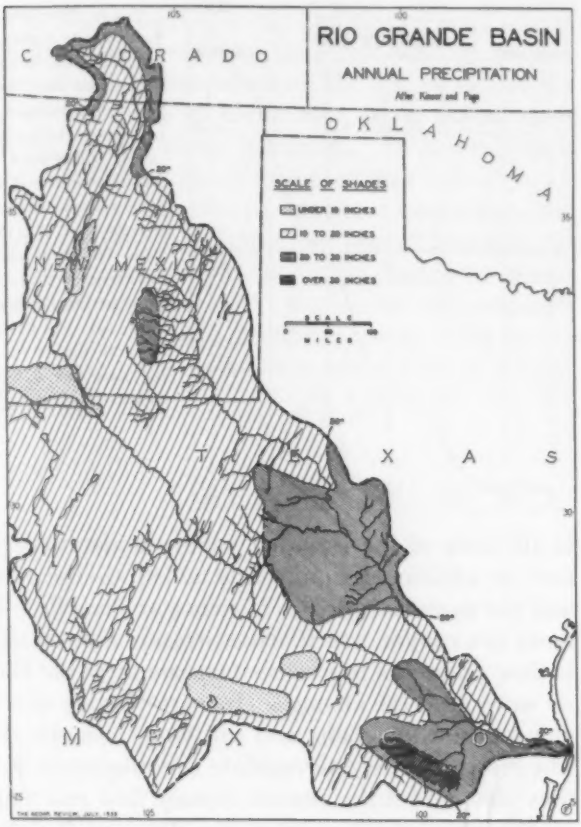

FIG. 3—Distribution of precipitation on the Rio Grande drainage basin. The distribution of precipitation over the drainage area varies from less than 10 inches in the low-lying bolsons to more than 30 inches in the high mountains, revealing the general aridity of the Rio Grande drainage basin. Details of distribution in the lower river are given by the author in "The Climate of the Lower Rio Grande Valley of Texas," *Monthly Weather Review*, Vol. 60, 1932, pp. 207–214.

The torrential convectional thunderstorm type of rainfall common to the area causes sudden floods in the tributaries, which bring down "walls" of water, mud, and débris resulting in more damage by clogging the flow than is balanced by benefits derived from the additional water.

scanty rainfall, while the Mexican tributaries rise in mountains that have a heavy precipitation (Fig. 3). As a result the Mexican tributaries furnish more than 70 per cent of the water that reaches the Lower Valley,[6] whereas practically all the water on the American side of the river is used.

The diversions of water from the Upper Rio Grande in Colorado and New Mexico, prior to the construction of the Elephant Butte reservoir, caused the main stream to run dry at El Paso, resulting in serious trouble from lack of water in the Juarez Valley below that point. In 1906 a new treaty was concluded which provided that the United States "shall deliver 60,000 acre feet of water annually to the Mexican diversion canal above Juarez." In consideration of this Mexico waived all claims to the water of the Rio Grande between El Paso and Fort Quitman.[7] Below that point, however, the water of the stream was joint property. With the closing of the Elephant Butte reservoir in 1916, practically all the water of the main stream

[6] Report of the American Section of the International Water Commission, *71st Congr., 2nd Sess., House Doc. No. 359*, Washington, 1930, p. 316.

[7] *Ibid.*, p. 315.

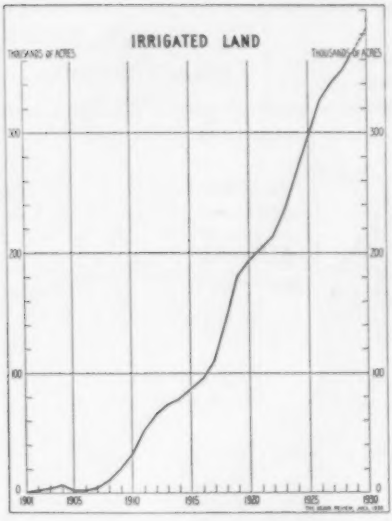

FIG. 4—The area under irrigation in the Lower Rio Grande Valley. There are three periods of rapid increase in irrigated area. The first period began soon after the completion of the railroad in 1904 and continued until about 1913, when bandit troubles on the border retarded growth. The second period commenced in the "boom" years during and immediately after the World War: but a period of slower development followed with the depression of 1920–1921. The third period began with recovery from the 1920–1921 depression and increased rapidly when the Southern Pacific lines started the construction of the second railroad into the valley. Since 1927 the curve of increase has not been so steep as during the preceding years, but during the past four years approximately 60,000 acres have been added to the irrigated area.

in the area of the irrigated valleys under that project was diverted, and no additional supply was added to the river between El Paso and the mouth of the Rio Conchos at Presidio. Fortunately the river flows in a canyon which makes irrigation impossible. The river begins to flow again as a pronounced stream after the Rio Conchos discharges its water into the channel. In 1916 Mexico closed the Boquilla reservoir on the Rio Salado, and will soon close others on the same stream. The reservoirs tend to regulate the minimum flow of the stream, but they also reduce the annual average flow reaching the Rio Grande.

For years the United States diverted the entire flow of the Rio Grande above the point where it becomes an international stream and thereby set a precedent. Should Mexico divert the waters of her tributaries to the Rio Grande it would cause a greater calamity to the economic development of the Lower Rio Grande than the one threatening the Juarez Valley before 1906. However, the present economic development of the northern states of Mexico renders the complete diversion of waters of the Mexican tributaries of the Rio Grande unlikely in the near future. Before the revolution of 1910, President Diaz undertook the development of a large enterprise in the Lower Rio Grande Valley of Mexico to irrigate about 100,000 acres in the State of Tamaulipas. Construction work was started, the canal partly completed, and some of the pumping machinery placed on the river bank when the revolution terminated development.[8] The project has never been revived, but should it be completed it would take a large supply of water from the Rio Grande below the confluence of the two streams.

[8] Equitable Use of the Waters of the Rio Grande below Fort Quitman, Tex.: Hearing before the Committee on Foreign Affairs, House of Representatives, *68th Congr., 1st Sess., House Rept. 8371*, Washington, 1924, pp. 12–13.

Thus the situation as to the equitable use and diversion of waters of the Rio Grande and its tributaries below Fort Quitman has become critical. Since the agricultural development on the Texan side of the delta uses practically all the water of the stream, some adjustments will have to be made concerning water diversion. An International Water Commission appointed to study the problem has been at work for several years. The American section of the Commission has suggested that "if Mexico should be willing, the United States could afford to construct a power plant for Mexico in exchange for unappropriated water from Mexican sources."[9] But so far no agreement has been reached, and a treaty that will distribute the water equitably and agreeably to both parties concerned is still awaited.

[9] Report . . . International Water Commission, *op. cit.*, p. 28.

LAKE MANLY: AN EXTINCT LAKE OF DEATH VALLEY

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Stanford University

IN the desert part of southeastern California and southern Nevada there are long parallel mountain ranges separated by troughs popularly called valleys, although they are unlike the ordinary valleys of humid regions and are probably of different origin. The deepest and one of the longest of these is Death Valley—once a place of mystery and gruesome tales but now fast becoming a winter resort for the motoring tourist.

Such human beings as may have roamed over the desert part of California and Nevada in late Pleistocene time could have looked down from the mountains that flank the great trough of Death Valley and have seen a beautiful blue lake about thrice as long as the present Pyramid Lake, Nevada, although not as wide. This now extinct lake has been appropriately named[1] in honor of W. L. Manly, who led and heroically rescued the first party of white emigrants who entered Death Valley in 1849.

Lake Manly was probably one of the temporary lakes that developed in the undrained basins of the desert region during a cooler and moister period. Today only a few of them remain—Great Salt Lake, Walker Lake, Mono Lake, Pyramid Lake, and others—but in that earlier time there were many more, and those that still exist were much larger.[2] In fact nearly all the arid basins, of which there are several hundred in the Southwestern states, then contained lakes.

So obscure is the evidence of the former existence of Lake Manly that most of the earlier geologists who visited Death Valley were skeptical about it. In 1925[3] Noble reported that he and Gregory had observed several lake-shore terraces upon a basalt hill near the south end of Death Valley. Here and there to the north other obscure terraces were revealed.

The record of the lake is to be found chiefly in its deposits and in the wave-carved terraces.

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[1] T. H. Means: Death Valley, *Sierra Club Bull.*, Vol. 17, 1932, pp. 67–76; reference on p. 76.

[2] For best accounts of these see G. K. Gilbert: Lake Bonneville, *U. S. Geol. Survey Monograph No. 1*, Washington, 1890; I. C. Russell: Geological History of Lake Lahontan: A Quaternary Lake of Northwestern Nevada, *U. S. Geol. Survey Monograph No. 11*, Washington, 1885; the same: Quaternary History of Mono Valley, California, *U. S. Geol. Survey, 8th Ann. Rept., 1886–'87*, Washington, 1889, pp. 261–394.

[3] L. F. Noble: Note on a Colemanite Deposit Near Shoshone, Calif., with a Sketch of the Geology of a Part of Amargosa Valley, *U. S. Geol. Survey Bull. 785*, Washington, 1926, pp. 63–73.

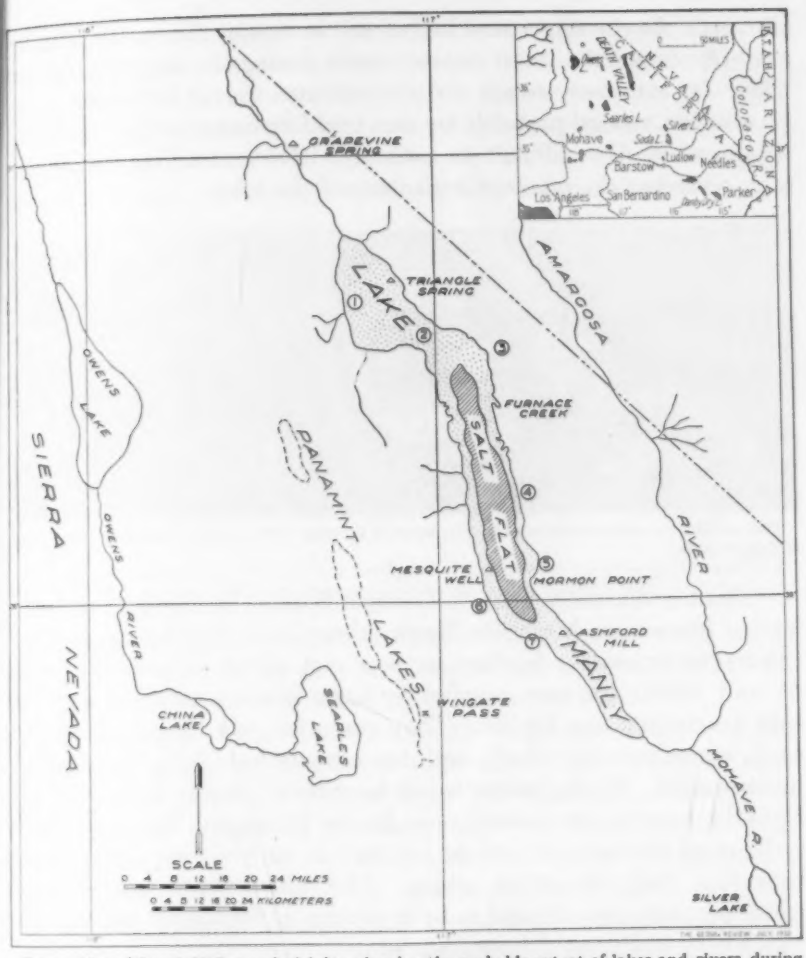

FIG. 1—Map of Death Valley and vicinity, showing the probable extent of lakes and rivers during the Tahoe glacial age of the Pleistocene period. The lakes of Panamint Valley are indicated in broken lines. Other lakes of the same age and the drainage during earlier glacial epochs are not shown. Numbers have reference: 1, outcrop of white chalky lake beds; 2, Salt Creek narrows (McLean's Well); 3, obscure lake terraces on foothills; 4, deposits of tufa on gravel near base of scarp; 5, obscure lake terraces near mouth of Copper Canyon; 6, series of lake terraces east of the Carbonate mine; 7, basalt slope with lake terraces and tufa.

The inset shows the area in relation to the desert region of southeastern California as a whole.

EVIDENCE OF THE EXISTENCE OF THE LAKE

Over a length of 45 miles the central part of the basin is floored with hard salt. As noted by Gale,[4] wells that have penetrated this uppermost sheet of salt, as well as actual exposures at the salt pools, show that it is less than 5 feet thick and that it rests on a layer of saliferous clay 25–33 feet thick. Beneath these a sequence of salt and clay beds continues to a depth that is undetermined but is at least

[4] H. S. Gale: Prospecting for Potash in Death Valley, California, *U. S. Geol. Survey Bull. 540*, Washington, 1914, pp. 407–415; reference on p. 412.

100 feet. As the uppermost bed of salt is now at the surface, it probably represents the latest deposit made during the desiccation of the lake. Its extremely rough surface indicates that it has wasted away by solution, caused probably by rain trickling down to the water table, to an extent now difficult to estimate. The underlying bed of clay may represent the phase of expansion of the lake.

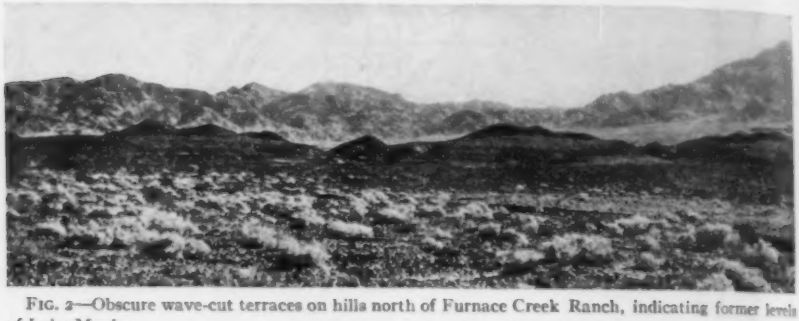

FIG. 2—Obscure wave-cut terraces on hills north of Furnace Creek Ranch, indicating former levels of Lake Manly.

About seven miles west of Triangle Spring, in that part of Death Valley known as Mesquite Basin, there is a broad area of white calcareous deposits. As they are now just above sea level they must be well within the area covered by Lake Manly, which at one time rose nearly 300 feet higher. They comprise pale olive-gray silt and sand, white powdery chalk, and dense white limestone, and they are much eroded. No distinctive fossils have been found in them, although algoid structures are conspicuous in the limestone; but the characteristics of the deposits are so peculiar as to leave very little doubt regarding their lacustrine origin. The white chalk resembles the white powdery deposit said to be in process of formation today by the alga *Chara* in Pyramid Lake, Nevada.

Unlike such lakes as Bonneville in Utah, Lake Manly seems to have no fossil deltas. The fluctuating level of the water would doubtless be unfavorable to the formation of such features. The rather small quantities of detritus swept in by the entering streams were probably smeared irregularly over wider areas and are now scarcely recognizable. Nor have any gravel spits, bars, or other embankments been observed along the old strand lines of Lake Manly. At any one level wave action must have been only transient and rather ineffective.

Among the plainest records of the ancient lake are the remnants of terraces carved during its declining phase. The best of these are on the northward-facing basaltic slope 1.3 miles west-northwest of Ashford Mill, near the south end of Death Valley. There at least twelve distinct terraces may be counted. The two most conspicuous are the highest terrace and the ninth terrace from the top. The former is bordered by a small cliff now largely obscured by a growing talus.

It seems to be about 310 feet[5] above sea level. The ninth terrace is 100–200 feet wide and stands about 50 feet above sea level. Several of the terraces, especially the uppermost, are strewn with well worn gravel and cobble stones. Calcareous tufa is scarce, but thin crusts of it were found on some of the pebbles. At the level of terrace Number 8 it is somewhat more plentiful, forming laminated crusts 2 to 3

FIG. 3

FIG. 4

FIG. 3—An example of the exceedingly rough surface of the salt plain in the bottom of Death Valley.
FIG. 4—Typical basalt pebbles from the wave-cut terraces west of Ashford Mill in Death Valley.

inches thick on the under sides of talus blocks. As new talus has already advanced so far as to cover some of the terraces almost completely it has doubtless concealed other masses of tufa.

Farther north, about six miles south of Mesquite Well, similar terraces can be seen on the alluvial slope east of the Carbonate mine. From the floor of Death Valley when the light is favorable these terraces appear almost as distinctly as those near Ashford Mill, though on close examination of them I found no proof of wave action. Another place where terraces can be seen at almost any time of day is on the low hills six to nine miles north of Furnace Creek Ranch. From a distance, four or more level terraces can be seen not far from sea level. But on ascending the southern and most promising hill I could find no definite proof of the presence of a lake. Even the terraces themselves are so obscure as to leave one dubious except in relation to the proved strand lines near Ashford Mill. Altimeter readings on the more prominent of the terraces north of Furnace Creek indicate altitudes of −40, +65, +180, and +195 feet, as referred to sea level. Allowing for probable errors in the instrumental data, these elevations agree rather closely with those of some of the terraces on the basalt slope in southern Death Valley.

Faint terraces have been observed at a few other points along the 200-mile shore line of Lake Manly—along the base of the Black Range just northwest of Mormon Point, immediately south of Copper Canyon, others very faintly marked as far north as the Amargosa sink, about

[5] All these altitudes were measured with a Paulin altimeter, checked against U. S. Geological Survey bench marks on the floor of the valley. The probable errors are less than 50 feet.

nine miles south of Furnace Creek, and west of McClean's Well. Usually only one or two strand lines are distinguishable in these localities.

Small masses of tufa have been found near the base of the Black Mountains scarp east of Tule Spring and also near Triangle Spring many miles farther north. In the former place it ranges from −200 to about +40 feet in altitude, and in the latter site it is found at about +30 feet. In neither locality is the tufa so distinctive that one can be sure it is not travertine, and hence of itself it would hardly serve to indicate a lake.

Lake Manly and Its Environment

The shore terraces indicate that Lake Manly rose to a level about 310 feet above mean sea level. At this stage it was probably about 90 miles long, 6 to 11 miles wide, and more than 585 feet deep. To the latter figure one should add 10 to 20 feet to allow for the sheet of salt and the part of the underlying clay that was deposited during the waning phase of the lake's history.

As Lake Manly had no outlet, the level must have been maintained at varying altitudes by the relation between inflow and evaporation. Today Death Valley is the driest known place in the United States, and even in the last glacial epoch evaporation may well have been rapid there. Such a lake may have been more or less saline in its early stages. During its rise to the maximum level the water of the lake may have been nearly fresh, becoming saline again by reversal of conditions during shrinkage.

The Amargosa River was probably the chief influent furnishing water to the lake. Other tributaries were a now nameless creek following the axis of northern Death Valley, as well as many small and perhaps intermittent brooks from the Panamint and Amargosa ranges. The Mohave River probably joined the lower Amargosa River by way of Silver Lake and Riggs Basin, but the obscurity of its ancient channel suggests that the flow was of brief duration at least in the last age of moist climate.

It has been suggested by Gale[6] and others that Owens River formerly poured into Death Valley by way of Wingate Pass, after filling Inyokern Basin, Searles Basin, and Panamint Valley. Although the evidence for this is meager, after going over the ground with care I am inclined to agree. From the contrast in state of preservation of the terraces and tufa in Searles Basin at the upper and lower levels, I infer that the basin overflowed into Panamint Valley in the Tahoe glacial age but not in the Tioga age. The filling of Panamint Valley to the 1980-foot level corresponding to the elevation of Wingate Pass

[6] H. S. Gale: Salines in the Owens, Searles, and Panamint Basins, Southeastern California. *U. S. Geol. Survey Bull. 580*, Washington, 1915, pp. 251–323; reference on p. 315.

must have occurred at the time Searles Lake overflowed. Hence it seems probable that the Wingate Pass outlet into Death Valley was functional during the Tahoe rather than the Tioga age.

Like Pyramid and Walker lakes of today, Lake Manly seems to have received most of its water at one end, in this case the southern end: hence its salinity probably increased from south to north as is the case in both of these lakes.

In spite of the dearth of fossils one may be sure that Lake Manly was by no means a dead sea. Its waters doubtless swarmed with the brine shrimp (*Artemia*) and the larvae of the fly *Ephydra*. Blue-green algae, some of which formed crusts of calcareous tufa, must have been common. Mollusks such as *Anodonta* and *Carinifex* and fishes such as the minnows (*Siphateles* and *Agosia*) and the top minnow (*Cyprinodon macularius*) may well have been present, since they now live in shrunken remnants of the streams that were then tributary to Death Valley. Anyone who has seen the thousands of grebes and phalaropes on Mono Lake (salinity about 5.5 per cent) or the gulls and pelicans that frequent Great Salt Lake (salinity 18 to 20 per cent) will readily picture to himself the wealth of bird life that sought the blue waters of Lake Manly.

Since the condition of Pyramid, Walker, and Great Salt lakes is today much as Lake Manly was in Pleistocene time, recourse to analogy enables one to picture the surroundings of the latter. The lower slopes of the mountains were probably clothed with green-gray sagebrush. Junipers and pinyons dotted the mountain sides above 3000 feet, and the higher canyons may have sheltered discontinuous groves of pine. Willows and cottonwoods formed sinuous belts along the streams, while the adjacent lowlands were sprinkled with greasewood bushes.

Age of Lake Manly

Either in the form of fossils or physiographic relations, direct evidence regarding the geologic age of the lake is almost wanting. Indirect considerations, however, have some value.

On account of their direct connection with glacial moraines, the old shore lines of Lake Bonneville in Utah and those of the expanded stage of Mono Lake in California are now tolerably well dated as belonging to the latest or Tioga[7] age of the Pleistocene period. The shore features of these lakes are, however, much more continuous and distinct than those of Lake Manly—an indication that they are younger.

The Owens River system of lakes previously described by Gale[8] I have traced by means of terraces and other physiographic features

[7] Eliot Blackwelder: Pleistocene Glaciation in the Sierra Nevada and Basin Ranges, *Bull. Geol. Soc. of America*, Vol. 42, 1931, pp. 865–922.

[8] Gale, Salines in the Owens, Searles, and Panamint Basins, p. 319.

almost continuously up to the glacial moraines along the base of the Sierra Nevada. Evidence of two lake stages related to the Tioga and the preceding Tahoe glacial stages has thus been revealed. In the obscurity of its shore features and the extent to which they have been completely erased by the action of floods and wind, Lake Manly resembles the ancient lake in the Panamint Valley, which was formed by the overflow of Owens River through the Searles Lake basin, probably in the Tahoe glacial age. Most of the other evidence available tends to substantiate the opinion that Lake Manly belonged to the Tahoe (or earliest Wisconsin) age of the Pleistocene period. The duration of the lake must have been short. The thin deposits of tufa and the weakly marked terraces suggest that a few thousand years or even a few centuries would have sufficed for their making.

Predecessors of Lake Manly

That Lake Manly was merely the last of a series of Death Valley lakes is clearly indicated by the alternation of salt and clay beds beneath the great salt plain. How many such beds there may be is still unknown, for no well has yet reached the bottom of the series. Each layer of salt probably marks the complete desiccation of a lake. The underlying bed of clay may then represent the growth and shrinkage of that lake before the salt began to crystallize. If this is correct, each brace of deposits—one of clay and one of salt—would indicate one lake, and Gale's[9] 104-feet well record would then show three lakes of rather long duration and several more transient ones.

That the Death Valley lakes were, at no very remote time, tributary to the Colorado River is indicated by the distribution of fishes in the Southwestern desert region. They[10] now survive in springs and short brooks which are the relics of streams once confluent. The top minnows (*Cyprinodon*) in the Amargosa Valley, in Salt Creek in north Death Valley, and in Owens River are practically identical. The same species lives also in the modern tributaries of the Colorado River. Closely related if not identical forms of the minnow *Agosia* are found in the Colorado, Amargosa, and Owens rivers. Both Owens and Mohave rivers harbor minnows of the genus *Siphateles*, which are barely distinct, while similar species of the sucker *Catostomus* live in Owens and Colorado rivers. The habits of all these fishes are such that they could hardly have attained their present distribution except by the integration of a river system including all the streams mentioned.

If such a connection with the Colorado River did in fact exist, one may reasonably infer that it was by way of those basins and

[9] *Idem*, Prospecting for Potash in Death Valley, p. 413.

[10] For information regarding the desert fish fauna I am indebted largely to Professor J. O. Snyder and especially to Mr. G. S. Myers of the Zoölogy Department, Stanford University. They believe that further study of the region will bring out many similar facts.

passes that would today afford the readiest outflow. The Death Valley tributary may indeed have consisted of a river and lakes extending southward and eastward by way of the Soda Lake, Ludlow, Amboy, and Danby basins to a point below Parker, Ariz. On this route the highest pass, which is just east of Ludlow, is about 1900 feet above sea level.

I have searched in vain along the mountain sides the entire length of this route for definite traces of old shore lines or lake deposits and for the notches that may have been cut by the outlets of such lakes. It is possible, if not probable, that in the earlier epochs of the Pleistocene period the postulated chain of lakes did exist and that their shore features have been almost wholly erased. Only the deposits of clay and salt, which are for the most part still buried, can be expected to furnish testimony.

A METEOROLOGICAL CROSS SECTION: THE KÖPPEN BIRTHDAY VOLUMES

Charles F. Brooks

ON the occasion of his eighty-fifth birthday the meteorological world has given the venerable Professor Wladimir Köppen three rounds of greetings and an encore in the form of three Köppen volumes and a supplementary number of *Gerlands Beiträge zur Geophysik*.[1] Thirty geophysical journals, published in thirteen different countries, and 127 geophysicists "of the entire earth and several generations" joined in sending these birthday greetings. The papers, in German, English, French, Italian, or Esperanto, many of them with summaries in two or three languages, fill 1545 pages. A complimentary volume was published in honor of Dr. Köppen on his eightieth birthday,[2] but so active had he been since that time, directing and writing a goodly portion of the Köppen-Geiger "Handbuch der Klimatologie," now appearing, as well as continuing his output of special articles and a second edition of his book, "Grundrisse der Klimakunde," that this new and greater tribute was eminently deserved. Though the contributors chose only the subjects that they thought Dr. Köppen would enjoy, the field of interest of our dean of meteorologists is so broad that the volumes constitute a monumental cross section of present-day meteorology. More than half the 121 articles have some geographic flavor, and there are 144 maps among the 398 illustrations. Some of these papers of interest to geographers will be summarized.

World Weather

World weather is the subject of several papers. Sir Napier Shaw offers a table of "harmonies and syncopations in the seasonal variation of atmospheric elements" (Vol. 2, pp. 351–352), including the seasonal variation in weight of air in the northern hemisphere. This ranges from five billion tons above the mean in January to five billion tons below the mean in July. During eight months the air is shifting across the equator at a rate of about two billion tons a month. L. W. Pollak correlates the monthly anomalies of air temperature at chosen places, especially Prague, with those of sixty other places all over the world (Vol. 2, pp. 70–111). January temperature in mid-Europe appears to be indicated to a useful degree by the preceding late summer and the autumn temperature in India, while for July the March temperature in Iceland and the May temperatures in central North America and in Persia are useful. C. F. Brooks shows a response of Gulf Stream temperatures in the Straits of Florida to variations in trade-wind strengths in the eastern Atlantic four to fourteen months previous (Vol. 3, pp. 400–408); and J. W. Sandström relates Gulf Stream temperatures to later abnormalities in Scandinavia (Vol. 1, pp. 254–259)—a warm body of water while in the mid-Atlantic favors southeast winds and a cold winter over northwest Europe (1928–1929); but, later, when it has reached the northwest part of the Norwegian Sea it favors southwest winds and mild weather over northwest Europe (1929–1930).

[1] Vol. 1, xii and 436 pp., maps, diagrs., ills., bibliogrs. (*Gerlands Beiträge* Vol. 32, Leipzig, 1931); Vol. 2, vi and 451 pp., maps, diagrs., ills., bibliogrs. (Vol. 33, 1931); Vol. 3, vii and 312 pp., maps, diagrs., ills., bibliogrs. (Vol. 34, 1931); Suppl., maps, diagrs., bibliogrs. (Vol. 35, Part II, 1932, pp. 130–262).

[2] *Geogr. Rev.*, Vol. 17, 1927, pp. 697–698.

The influence of volcanoes on world weather, through the screening effect of the fine ash in the atmosphere, is touched upon by Immanuel Friedlaender in a general paper on volcanic eruptions (Vol. 1, pp. 113–133). After emphasizing the value of topographic and gravimetric surveys of volcanoes and also magnetic measurements, he indicates that meteorological observations are also worth while. In fact, the first volcano observatory was founded as a meteorological observatory. A volcano may cause great rain gushes, the water coming directly out of the volcano both in the fluid and vapor states and also condensing from the atmosphere on volcanic dust nuclei. Most of the water, Friedlaender believes, is magnetic. Since the aspect of a volcano changes with the weather, it is a good prognostic. The density of condensation from fumaroles is markedly affected by the humidity, and the form of the crater cloud by the wind. Clouds condensing from the atmosphere around the peak are also significant.

Cyclones and Frontal Phenomena

The discovery of fronts in the tropical cyclones of the Indian Ocean, here summarized by C. W. B. Normand (Vol. 3, pp. 233–243), has already been reviewed in this journal.[3] Another important contribution is Father E. Gherzi's note on extratropical depressions in China (Vol. 1, pp. 368–378). In winter, when offshoots from the Asiatic anticyclone move eastward out to sea from China, a tongue of tropical air marked by an extension of the normal low pressure of Indo-China invades southwestern and central China. It is first marked by fog, then by low cloud. The cold air on the north attacks the tongue and cuts off from one to three or more pieces, which then drift eastward or east-northeastward as independent lows. These form most frequently in spring. Other lows, already formed, enter western China and are sometimes marked by sharp cold fronts. This cold air has been found by aviators to push its way under the warmer air. What the shape of the cold front is and what happens at different heights as it advances can now be determined most readily in Europe, where atmospheric soundings are made at several stations not widely separated. A blunt front with top rising west or northwestward seems typical. E. Palmén shows that a fall in temperature at a moderate height to a distance of 100 kilometers in advance of the front occurs as a result of the forced ascent and expansional cooling of the warm air that must get out of the way of the advancing mass of cold (Vol. 1, pp. 158–172). In a detailed paper on storm frequency in the Baltic region, L. Schubart presents new storm-track maps of Europe (Suppl., pp. 230–240). These paths followed by lows show clearly that they are attracted by the seas.

The valley breeze as observed in Java is discussed by C. Braak, who asserts that, since the breeze starts first on sunned slopes, its cause is mainly local heating of the slopes rather than general expansion of air in the valley (Vol. 1, pp. 83–86). Further support is given by the midday clearness of the weather over the valleys in contrast to the cloudiness and raininess of the slopes and by the opposite conditions at night —fair on slopes but cloudy and rainy over the valleys.

E. Kidson presents a clear picture of the general circulation in the latitudes of New Zealand (Vol. 3, pp. 1–8). He finds it best to refer to the moving anticyclones as eastward-moving waves. The high pressures are strengthened (in winter) or weakened (in summer) in passing over Australia, where the local influences partially obscure the basic intensity and regular march of the waves. The normal alternation of wind directions between the bands of northwesterly and southwesterly winds is in itself sufficient to produce frontal phenomena. There is a striking correlation between the mean latitude of anticyclones and sunspot numbers, higher mean latitudes going with sunspot maxima and lower with sunspot minima.

[3] *Geogr. Rev.*, Vol. 23, 1933, pp. 142–143.

Great Dust Storms

Describing the dust falls in Spain in October, 1926, and November, 1930, F. Pardillo gives a general review of great dust storms in Europe and indicates the magnitude of these two (Vol. 3, pp. 310–332). The 1930 storm deposited a quantity of dust over southern France as well as over Spain. If the catch of one gauge, which was equivalent to 32.75 tons per square kilometer, was representative, and if the area was 440,000 square kilometers, the dust fall was of the order of 16,610,000 tons. The 1926 storm yielded only 1.75 tons per square kilometer and was more restricted in area. The material, including uneroded zircon crystals, apparently came from the El Areg dune area south of Algeria and just north of the Ahaggar massif, in the west-central Sahara. Edward Stenz describes the great Ukrainian dust storm of April 26–30, 1928, which was due to a terrific earth-raising hurricane that, from 130,000 to 400,000 square kilometers, swept about a billion tons of soil into the air, making day as dark as night (Vol. 2, pp. 313–337). The level of the ground was lowered eight to twelve centimeters. While most of the soil was deposited in drifts in the Ukraine, some two million tons fell on Rumania and a million and a half tons on Poland. The dust fell out of the air during a period of twelve hours to four and a half days. The frequency of such storms is about seven in a century. The storms of 1886 and 1892 blew so much soil away as to render certain areas uninhabitable. The sanding of the Caspian Sea near Astrakhan is 0.3 millimeter annually.

Equivalent Temperatures and Other Phases of Climate

Several phases of climate heretofore not considered important are developed and illustrated. Sunshine on precipitation days, to show the degree of sunshine and showers in a climate, have been derived by Anton Huber for representative environments in central Europe (Vol. 2, pp. 118–124). It is illuminating to know that half the midsummer sunshine in Bavaria and the Alpine area occurs on days with rainfall and that in the months April to August from 65 to 93 per cent of the days with precipitation also have bright sunshine. The Rhine plain, with 46 to 53 per cent, is only slightly less sunny on rainy days. A climogram of hours of sunshine on rainfall days versus the number of days with rainfall shows that the Alpine area has more sunshine than Bavaria in spite of having more rainfall days.

Rainfall per rainy day is shown by K. Knoch to be very largely of tropical-shower type on the western slope of the cordilleras in Colombia (Vol. 1, pp. 353–360). At Buenaventura, a three-year record shows an average rainfall of 9021 millimeters, which falls on 326 days. On 25 per cent of these days the daily amounts are 20 to 50 millimeters, on 3.5 per cent more than 100 millimeters falls, and on one day there was 223.5 millimeters. At Bogotá, on the highlands, where the annual rainfall is 883 millimeters on 179 days, the most frequent daily falls are 0.1 to 1.0 millimeters.

Another phase of climate, called equivalent temperature, is receiving considerable attention as an approximation to the hotness felt by man. In the absence of widespread data on "cooling powers" of different climates, the equivalent temperature, which is the temperature the air would have if all the latent heat represented by the vapor in it were used to raise the temperature, is a good substitute. It is conveniently computed roughly by adding to the temperature in degrees centigrade twice the vapor pressure in millimeters. E. Biel and O. Moese have discussed the climate of Japan in terms of both actual and equivalent temperatures (Suppl., pp. 241–262). On a more extended scale, Walter Knoche has mapped the equivalent temperatures of South America (Suppl., pp. 189–203). The hottest is the interior of British Guiana, with an equivalent temperature of 73.2, but Maracaibo (72.2) and Willemstad and Paramaribo (over 70) are almost as hot. The interior of the Deccan, India, is 83 in summer. New York ranges from 53 in the warmest month

to 5 in the coldest, being even hotter than Rome (51) in July. Artificial cooling is necessary where the equivalent temperature exceeds 60, is desirable for over 40, and valuable above 30. "Life in the tropics will become more comfortable," wrote the late R. DeC. Ward, "as well as safer for the white race, but acclimatization, in its full and literal sense, seems impossible" (Vol. 1, pp. 149–157).

Climatic Change

Changes of climate is a live subject. H. P. Berlage, Jr., has found by measurements of tree growth in Java that the well known three-year weather cycle could be pursued more than four centuries back (Vol. 1, pp. 223–225). Its average length is 3.32 years. Rudolf Meyer presents a new definition of climate, which includes "when" as well as "what" (Vol. 1, pp. 418–427): "The single aim of climate is the simple and comprehensive presentation of the influence exerted by the weather of a long time on man, animals, plants, soils, etc., and the general dependence of this weather on terrestrial and extraterrestrial influences." Climatic values are not chance sequences; the departures tend to hold the same sign and to reveal periods. Since the succession is controlled, there is no compensation of cold for warm. Time is an element in climate—all averages and maps should carry their inclusive years. There is no incompleteness to climatic data even if periods are short. Accuracy is the prime essential. What you have reveals the climate to the extent that the period makes possible. There is no period of years that can be said to represent the climate fully. Perhaps we should have normals for each quarter of a century.

Coching Chu, using phenological data, floods and droughts, earliest frost and snow, and the number of severe winters, also instrumental records, finds an appreciable variation from century to century in China (Vol. 1, pp. 29–37). The ratio of floods to droughts ranges from 1.04 to 8.20 a century, and severe winters from 9 to 35 a century, the variation in numbers holding a fairly close parallel to those in Europe. Instrumental records, which, however, have covered a relatively short period, show extraordinarily little change between the periods 1841–1874 and 1915–1924. The mean annual temperature differs by only 0.1° C. In the recent period, the climate was a little more continental, the temperatures being more extreme and the rainfall slightly less, 576 millimeters as against the earlier 652.

Another region where a possible change of climate is of great historic interest is the Maya region of Yucatan and Guatemala. Karl Sapper believes that the destruction of forests with their humid quiet microclimate, soil erosion, and, to some extent, volcanic ash, have reduced the livability of the region (Vol. 3, pp. 333–353). New diseases are also a factor. But these are negative. The more favorable local climates, better soils, etc., could not have supplied the energy necessary for the development of the ancient Mayan civilization. Sapper agrees with Huntington that there must have been a cool season and considers that the evidence of greater rainfall in California as shown by the big trees points to the likelihood of cooler winters in Yucatan and Guatemala at the periods when the civilization was highest.

Changes of climate for the earth as a whole are considered by several authors. Wilhelm Halbfass (Vol. 1, pp. 173–191) does not think the earth is drying up. Sea level has not changed, and rivers in general have been constant for the past 100 years. There is evidence that Central Asia is getting drier and that northern Uganda is drying up, but he finds no appreciable change in Palestine in 3000 years.

The Wegener-Köppen Theory of Climatic Change

The question of changes of climate from polar migration in consequence of the floating of continents is a subject very close to Dr. Köppen, for he and his son-in-law, the late Dr. Alfred Wegener, who died on the ice cap of Greenland, wrote a book

proposing this theory of climatic change. Hans Ertel has derived a new formula for the equatorward force of continental wandering and polar shifting (Vol. 1, pp. 38–46); Wenceslas Jardetzky shows that under the assumption of the earth's crust turning at a different rate from the viscous core, and the irregular distribution of continental masses, a very slow continental drifting should occur, which by computations is shown to be adequate to account for the changing position of the earth's axis (Vol. 1, pp. 361–367). P. A. Loos's study of the catastrophic earthquake of May 30, 1929, in Chile and its relation to quakes in 1927 and 1928 indicates that Chilean earthquakes are deep-seated, while Argentinian quakes are shallow, and that South America is pushing westward over the dense bottom of the Pacific (Vol. 1, pp. 208–222). M. W. Senstius finds that the laterites on the east of the Black Sea can be accounted for well by the Wegener-Köppen theory, for they appear to be fossil soils formed in the late Tertiary under a hot tropical wet and dry climate, which is the climate that theory indicates should have occurred there at that time. The bauxite-laterite deposits of Surinam, France, Istria, India, and the Malay Archipelago can be explained by similar considerations (Vol. 1, pp. 134–140).

The Classification of Climates

Since Dr. Köppen is most widely known for his admirable classification of climates, it is not surprising to find seven contributions on this theme. Rudolf Geiger and Hermann Zierl compare Köppen's climatic zones with the vegetation zones of Africa (Vol. 2, pp. 292–304). The two do not always correspond, for climate is not the sole control: where there is a considerable annual range of rainfall a water-holding soil may support a tropical forest, while a pervious soil must have grassland. With Köppen's climatic map as a background, the distribution of vegetation makes possible an interesting analysis of climate and ground characteristics. On another southern continent, Griffith Taylor applies Köppen's classification again and discusses in detail the limits of the Australian desert (Vol. 2, pp. 16–30). Some parts of Australia with less than 5 inches of annual rainfall are occupied, others, with 5–15 inches, are not. Lack of suitable food—certain types of desert plants—rather than water determines use of the land for cattle. K. T. Kirof applies Köppen's classification to Bulgaria (Vol. 1, pp. 205–207). Count Teleki presents ideal (snowshoe) diagrams of all French, Russian, United States, and British territory and praises the classification for its scale of agricultural usefulness, which is very helpful in teaching political geography (Vol. 1, pp. 282–287). F. Linke has also found the Köppen classification a great help in teaching (Vol. 1, pp. 275–281): he ascribes the lukewarm adoption of the classification to inapplicability of the formula for research and to the fact that similar climates are thrown together though due to different causes. But on the other hand the classification brings out the broad features and makes a bridge between pure meteorology and biology, geography, and agriculture.

The general Köppen method of classifying by letters and subscripts is applied by A. N. Livathinos in making a detailed classification of the climates of Greece (Vol. 1, pp. 95–99). The country is divided into groups according to temperature (5), rainfall (6), relative humidity (7), and cloudiness (4). For comparison he takes fourteen stations for a profile from the equator to latitude 70° N. To express a climate, 6 aspects of temperature, 6 of precipitation, 3 of relative humidity, and 3 of cloudiness, mostly annual and extreme monthly values and ranges, are coded in capital and small letters. O. V. Johansson presents a classification of world temperature types according to latitude and continentality and applies it to 68 stations (Vol. 2, pp. 406–428). E. Alt uses the mean departure of monthly mean temperatures as a measure of continentality and presents maps of Europe showing lines closely paralleling the general coast (Vol. 1, pp. 141–148).

The Meteorological Equator

The expression "heat equator" or "thermal equator," as commonly used for a line varying widely with the seasons, is an inappropriate use of the word "equator," writes Otto Tetens (Vol. 1, pp. 336–345). The equator is very nearly constant in position through the year. He prefers to use the term "thermal" or "meteorological equator" for the dividing line between northern and southern temperature régimes, or between the regions with the January and the July half-years the colder. Where January and July temperatures are equal you have the meteorological equator. For a more exact determination the temperatures of the half-years centering on February 1 and August 1 should be compared. The meteorological equator lies about 1 degree north of a great circle cutting the geographical equator at an angle of 5 degrees at longitude 90° and reaching farthest north on the Greenwich meridian and farthest south at 180°. A rainfall equator might be made on the basis of seasonal rainfall, using monthly intensity of rainfall per day as the units for comparison and so avoiding reduction of the monthly rainfall amounts to those for twelfths of a year.

Snow Cover and Precipitation in the Alps

Duration of snow cover is not often discussed, yet it is highly important both with respect to air and soil temperature and to the brightness of a climate. V. Conrad and M. Winkler, with records from 342 stations in the Austrian Alps, show that the duration of snow cover ranges from 38 days at 200 meters to 218 days at 2000 meters (Vol. 3, pp. 473–511). The duration in different years fluctuates greatly at low altitudes (32 per cent at 400 meters) but is fairly consistent above 1200 meters (less than 10 per cent). Inner valleys have lesser duration, and outer ones, especially those on the windward side of a range, have longer snow cover by as much as two months either way at the most sheltered and exposed stations at 800 or 900 meters. The depth of snowfall dominates the duration. The ratio of snowfall depths in millimeters to the number of days with snow cover is 0.32 to 0.45. Sunny sides of valleys correspond to the dry lee slopes, and so the ratio there is about the same as elsewhere. J. Maurer shows that the precipitation in the Swiss Alps increases to the greatest heights, rapidly to 2200 or 2800 meters, then at about half the rate above that (Vol. 1, pp. 346–352).

Regional Climatology

The temperatures of Finland in relation to agriculture are fully discussed by J. Keränen (Vol. 2, pp. 261–267). Spring is but a short transition season, with remarkably quick growth of vegetation. The snow cover stays so long that spring work does not begin till May. Planting quickly follows and, on account of the short nights, crops are usually not in danger of frost till late summer, by which time, however, the quick-growing crops have had a chance to mature unless the spring was late. Thus the damaging effect of a late spring is notable: after 70 per cent of late and cool springs the summer crops are destroyed by autumn frost. Growing-season temperature sums range from 750 in the north at the potato limit to 1450 a little inland in the southwest, where most temperate-zone staple crops can be raised. General crop failures number 20 in 100 years, not sprinkled but grouped. Harald Lunelund, in presenting the radiation in Finland, shows that reflection from snow in winter and the pure air of summer give that northern country good insolation (Vol. 1, pp. 242–253).

Filippo Eredia presents the relative humidity of Italy with tables of 50-year averages for 25 stations by months (Vol. 2, pp. 286–291). The maxima come generally in December, but at the head of the Adriatic in October. The minima are almost invariably in July. Monthly averages in winter are generally 70–85 per cent and in summer 45–69 per cent. Autumn is appreciably damper than spring.

Ocean Currents, Soils

H. Thorade shows that tongues of warmer or colder water on ocean temperature charts do not necessarily indicate a current there (Vol. 3, pp. 57–76). Thus, the southwestward tongue of warm water south of the mouth of the Congo River is not a southward current. All the water is moving northward. V. W. Ekman, discussing the problem of the Gulf Stream in mid-Atlantic describes the situation as a waterfall between the plateau of warm water to the south and the cold to the north (Vol. 2, pp. 353–364). The contrast is the occasion for the eastward current, but the prevailing westerly wind is responsible for its narrowly confined character.

Soils are not neglected. L. S. Berg claims that "loess and loess-like soils have one common origin—they are formed in situ from various rocks, always highly calcareous, being the result of weathering and soil formation in the conditions of a dry climate" (Suppl., pp. 130–150). W. Lozinski, discussing the western margin of the Eurasian steppe in Poland, proposes the following identification of a steppe soil (Vol. 3, pp. 412–435): black earth of humus with a carbonate layer. It may be dry or wet. As subdivisions there are steppe black earth—moister and heavier and with more clay—and loess black earth with less clay. Steppes with occasionally water-filled depressions are called *poplaw*.

Conclusion

In conclusion a tribute must be given the editor of these encyclopedic volumes, Dr. V. Conrad. He touched the sources of research with the magic name of Köppen, and there poured forth scores of contributions. Though taken by surprise by such a flood of manuscript, Dr. Conrad, with remarkable energy and ability, impounded the flow and brought forth the most notable group of spontaneous papers representing the world's thought on meteorology and climatology that has ever appeared.

THE EXPANSION OF THE WHEAT AREA IN ARID RUSSIA*

Review by V. P. Timoshenko

THE question of expansion of the wheat area on new lands in Russia is very real at the present time when world overproduction of wheat may be considered as one of the important factors in the world-wide depression. There are divergent opinions on this question. Dr. C. F. Marbut estimated as very great the possibilities for a further expansion of the wheat area on the black and chestnut soils of Russia, particularly in Siberia and Central Asia.[1] I presented a less optimistic point of view in my book on the wheat problem in Russia,[2] which gave Dr. Marbut an opportunity to question my conclusions.[3] "Die Getreidewirtschaft in den Trockengebieten Russlands" by three Russian authorities on geography, agronomy, and agricultural economics confirms in great measure the conclusions at which I arrived. The work is based on a detailed analysis of geographical and agronomic factors such as I was unable to make in my study, to which the volume under review is thus complementary. The conclusion is that natural factors limit a rapid expansion of wheat production in Russia much more than is generally accepted in view of the enormous geographic area of Russia and its thin population in the Asiatic part.

Temperature and Rainfall Disabilities

The analysis of climatic conditions in the Russian steppe belt shows great variations in the climate from west to east, contrary to Dr. Marbut's statement that "the east-west trend of the belt and the very slight differences in elevation indicate that the differences in temperature are small. The evident uniformity of temperature, rainfall, and soils and the occurrence in a region of great smooth plains all combine to produce a belt of uniform characteristics and capacities."[4] Detailed analysis of climatic conditions shows that the belt as a whole is far from uniform in characteristics and capacities. Conditions are much less favorable for agriculture in the eastern part of the belt. Continentality increases markedly in this direction. While on the western borders of the Russian steppe the difference between the average July and the average January temperature is 45° F., in the region of the Volga the difference is over 60°, and in practically all the steppe area of Kazakstan and Siberia it is over 70°. In the western part of the black-soil belt the winters are rather mild, with an average January temperature of above 20° F., while in the steppe of Kazakstan and of Siberia, even in their southern parts, the winters are very cold: an average January temperature of about 0° F. and even below is typical for the steppe area of these regions. The growing season, furthermore, is very short.

The rainfall also is far from being uniform throughout the Russian steppe belt. The yearly rainfall in the western European part of the steppe varies from 12 to 20 inches, in the greater part of the area even from 16 to 20 inches. In the Asiatic

*B. Brutzkus, W. von Poletika, and A. von Ugrimoff: Die Getreidewirtschaft in den Trockengebieten Russlands: Stand und Aussichten, *Berichte über Landwirtschaft*, No. 67 (N. S.), Berlin, 1932.

[1] C. F. Marbut: Russia and the United States in the World's Wheat Market, *Geogr. Rev.*, Vol. 21, 1931, pp. 1–21.

[2] V. P. Timoshenko: Agricultural Russia and the Wheat Problem (Grain Economics Ser., No. 1), Food Research Institute and Committee on Russian Research, Stanford University, California, 1932.

[3] *Geogr. Rev.*, Vol. 23, 1933, pp. 159–160.

[4] Marbut, *op. cit.*, p. 8.

part of the steppe the yearly rainfall varies from 6 to 16 inches; the greater part lying to the south of the 12-inch isohyet must be classified as extremely arid. Practically the whole belt of dark chestnut soil in the Asiatic steppe receives less than 12 inches of rainfall during the year, in some regions even less than 8 inches. Even the southern part of the chernozem belt in Asia receives less than 12 inches of rainfall. During the three spring months (March-May) the greater part of the steppes of Kazakstan receives less than 2 inches of rainfall. Furthermore, deviations from the monthly average are frequent and great, and there are frequent long periods of complete drought with hot, dry winds (*sukhovei*). Because of these climatic conditions much the greater part of the belt of chestnut soils in Asiatic Russia is less suitable for crops than that in the European part of the steppe. Even some parts of the chernozem of this region can not be regularly used for crops.

Russian agronomists put the limit for regular crop production farther into the arid regions than is commonly accepted for the Great Plains of America. That is, Russian agronomists accept the yearly isohyet of 12 inches as the limit of normal and regular crop production,[5] while for America the isohyet of 15 inches is given as the lower limit for normal grain-crop production.[6] But even with this 12-inch limit the greater part of the steppe area in Central Asia is outside the area suitable for crops. Within the area having 8 to 12 inches rainfall some crop production is possible and is accomplished now, particularly by the seminomadic population; but these areas are unquestionably better for grazing, and crop production here must be combined with the raising of livestock: such is the native practice. These lands are not well fitted for the one-sided wheat production usual in state grain farms, even if the soils are favorable.

The climatic disability is one reason why Marbut's estimates, which are based on soil characteristics and not on an analysis of climate, exaggerate the possibilities of wheat expansion in Asiatic Russia. His estimate of the possible wheat area in the Russian steppe was 854.5 million acres as opposed to only 234.5 million acres of corresponding area in the United States. But in this comparison Marbut excludes from the chernozem and chestnut-soil belts of America the climatic region not well fitted for wheat production (though they are perhaps very favorable for other crops—such as, for example, cotton in Texas). He also excludes regions where wheat production was little developed for other reasons (for instance in western Nebraska and South Dakota), and he singles out only those parts of the chernozem and chestnut belts in America actually used for wheat crops to compare with the whole chernozem and chestnut-brown soil belts of Russia, including large areas in Central Asia not suitable for any crop production.

Unfavorable Soil Factors

Furthermore, the characteristics of the soils themselves are less favorable in the Asiatic part of the chernozem and chestnut-soil belts than Marbut believes. Large areas of the chestnut-brown soils in the southeastern part of European Russia and in Kazakstan contain an injurious concentration of salts (*solonchak* and *solonetz*). A large part of the chernozem of Siberia contains too much salt for satisfactory crop production. The book under review pays special attention to an analysis of the causes of this phenomenon. These characteristics of the soils create serious obstacles to the expansion of crop land in Central Asia and Western Siberia. But certain areas of fertile soils must also be classified as of inferior quality because of the climatic disabilities described above.[7]

[5] Such a limit was still advised at the grain conference of 1931 in Soviet Russia—see page 55 of the book under review.

[6] J. B. Kincer: The Climate of the Great Plains as a Factor in Their Utilization, *Annals Assn. of Amer. Geogrs.*, Vol. 13, 1923, pp. 67–80; reference on p. 68.

[7] Timoshenko, *op. cit.*, pp. 43 and 503.

Farming Practices and Methods

The book under review is also illuminating in its discussion of farming practices and methods. One section, by A. von Ugrimoff, describes dry farming as developed in the agricultural experiment stations of Russia during the several decades of their existence, that is since 1880. Another section, by B. Brutzkus, analyzes the results of the Soviet efforts at expansion in the form of the great state grain farms—grain factories. The conclusions of this analysis, which is brought up to 1932, show that in spite of the machine technique the factories are no more resistant to drought than are peasant farms in these arid regions. On the contrary, the drought of 1931 greatly affected the state farms in Kazakstan and the Lower Volga region, and the Soviet government found it desirable in 1932 to curtail the area of the state grain farms in these regions. Of the total crop area of the state grain farms in 1931 only one-fifth was in Kazakstan and the Lower Volga. Accordingly, the original plan to develop grain factories mostly in arid regions on unoccupied lands was replaced by the development of state grain farms in more humid and more inhabited areas. Instead of extending the crop area in unsettled regions, state farms supplanted peasant farming in settled regions. In the steppe of Kazakstan before the war peasant colonists were advancing their settlements to the 12-inch isohyet, even to the 10-inch line, organizing crop farming on extensive lines by combining it with the livestock industry. Dry farming specialists in Russia emphasize the fact that one-sided grain farming is exceedingly unstable in the arid regions and advise diversified farming, combining the production of small grains with hay and cultivated crops and the livestock industry. But this type of farming is much better fitted for peasant farms than for huge grain factories with their complete mechanization and specialization.

The problem of maintaining fertility of the soil in these arid regions lies not so much in supplying nutritive elements, in which the soil is sufficiently rich by nature, as in sustaining its structure. Cultivation, particularly one-sided use for small grain crops, tends to destroy the structure and turn the soil into a fine powder. Under extensive farming practice the structure is restored by allowing the land to lie fallow for several years and using it in the latter part of the period for grazing. In consequence less than a half of the total area is actually used for crops. It may well be that such a system is the best for the arid regions in the Asiatic part of the Russian steppe distant from markets. It is difficult, for these reasons, to accept the idea that in the area of chestnut soils there is no other use for land that may compete with wheat. Utilization of the lands of the chestnut belt in Central Asia for grazing may be economically more advantageous than their use for wheat. Especially is this true under Russian conditions, since Russia has always been deficient in animal products and has had large surpluses of wheat.

Colonization of the unoccupied lands, however, must proceed slowly because the better areas are already sufficiently occupied and those remaining require reclamation and improvement. This applies not only to the more humid regions to the north of the steppe area but also to the steppe itself. If the process is slow, one can hardly expect a rapid growth of wheat production as a result of the occupation of new lands; in fact, the increase in wheat production may not be more rapid than the growth of the population, especially if the population growth continues at the same rate as during 1923–1928.

Review by C. F. Marbut

"Die Getreidewirtschaft in den Trockengebieten Russlands" concerns the capacity of the Russian steppes, especially those of Siberia, for the production of wheat. It discusses both the chernozem and chestnut-colored soil belts and concludes by placing a lower estimate on their capacity than I have done. The lower estimate for the chernozem belt is based mainly on the presence of solonetz and

solonchak ("alkali"). For the chestnut-colored belt conclusions are drawn from analysis of climatic data, from comparison of the natural vegetation of this belt in Siberian and European Russia, and also on the presence of "alkali."

That part of the climatic discussion concerned with temperature does not demand attention. However much the low winter temperatures may constitute a disadvantage from the point of view of peasant colonization, no one can seriously maintain that the growing season is too short for the safe ripening of spring-sown grain. The strong emphasis on the presence of "alkali" is justified to a slight degree only. No Russian pedologist has ever stated that the presence of "alkali" in the chernozem and chestnut-colored soil belts will seriously interfere with their use in grain growing. Furthermore the extent of the area so affected has been grossly exaggerated. Glinka[1] mentions the presence of solonetz and solonchak in both belts in Siberia and illustrates the occurrence of the former by a photograph. Presumably the locality selected by him is typical. It shows one spot in the foreground and faint suggestions of one or more in the distance. The spot in the foreground seems identical in size and character with those that are common in the spring-wheat region of the United States and Canada. These spots are about 20 feet in diameter. Not only do they occupy a relatively small part of the total area, but they are not entirely barren, though the yield is lower than on the surrounding normal soils. Thousands of bushels of wheat are produced on land in Canada, the United States, and Hungary where they occupy a larger proportion of the total area than in Siberia, if Glinka's illustration be representative.

Glinka and Zacharov[2] both say that these spots become more abundant southward. Glinka does not go into details, but Zacharov, both in his text and on his soil map, shows that they are not abundant, except locally, until the dark-colored chestnut soil belt has been passed and the belt of brown (sometimes called the light-chestnut) soils has been reached. In the region north of the Caspian along and east of the Volga, Zacharov shows the presence of "alkali" spots along the southern half of the chestnut-colored soil belt and therefore in that part of it now generally designated as the light-colored phase, extending as far eastward as the longitude of Orenburg. He does not indicate their presence in the northern part of the belt even along the Volga and Ural rivers. In the Akmolinsk part of the belt he indicates the presence of scattered areas mainly, however, along the southern side of the belt. The occurrence of true barren salty soils outside of the Volga belt, and here mainly in the southern part, is confined to scattered low spots and to river valleys.

Indices of Productivity

Poletika lays great stress on the low rainfall in both the chernozem and chestnut-colored soil belts. Rainfall is much used as an indirect means of arriving at the productivity of a region but it is liable to lead to erroneous conclusions, for production depends on effective moisture during the growing season rather than on an absolute amount of rainfall. Since, however, direct attack is not possible for a large part at least of the chestnut-colored soil belt, this, it must be granted, is a possible method. In my own paper I used soil characteristics as the basis for my conclusions, another indirect approach but one based on more reliable data for the region as a whole than that through the rainfall.

The question may be raised, however, as to which is the safer line of approach, assuming that the data for each are equal. Every pedologist will decide unhesitatingly for soil characteristics, especially when regions with dry-land or grassland soils are the subjects concerned. He has learned through comparative studies

[1] Asiatic Russia: Publication of the Emigration Office of Main Office for Land Improvement and Agriculture, St. Petersburg, 1914, Vol. 2, pp. 7–24 (in Russian).

[2] S. A. Zacharov: Course in Soil Science. (Scientific Handbooks for High Schools.) Govt. Publ. Dept., Leningrad and Moscow, 1927, p. 385. (In Russian.)

extended over the grasslands of the world that the density of the grass cover that has grown on these soils is expressed by the intensity of their dark color. Thus the dark chestnut-colored soil shows by the darkness of its color that it has supported a good cover of grass, and hence that in spite of low rainfall the effective moisture is sufficient for that purpose.

The grains are grasses, and wheat is, in its characteristics as a plant, similar to the natural grasses growing on the dry grasslands of the temperate zones. The pedologist, therefore, without hesitation accepts a dark color as, in a measure, an expression of the capacity of grassland soils to produce wheat, other things being equal. Zacharov states that the dark-colored chestnut soils are much more important agriculturally than the brown (light-colored chestnut) soils and states also that the chestnut-colored soils are adapted to the production of wheat by dry-farming methods. Tulaikov's work at the Saratov station is devoted entirely to the study of methods to be used on the chestnut-colored and drier soils, consideration being given to the development of methods by which the peasant settler may fortify himself against droughts. That these soils may be used by large-scale dry-farming methods for wheat growing is accepted as a starting point. How they may be colonized safely by the peasant is being sought. The work under review seems in places to confuse the adaptability of a region for safe peasant colonization with its use merely for producing wheat.

Stronger evidence than any yet brought forward is necessary before it can be concluded that nature has deceived man by presenting to him an unproductive dark-colored soil developed under low rainfall. Until more data has been accumulated we must still conclude that the extension of wheat growing in Russia depends on the Russians rather than on Russia.

Professor Timoshenko brings forward only one additional evidence for the support of his former viewpoint. This is the destruction of soil structure by cultivation. Since this danger has not yet threatened production in Canada, the United States, and Argentina, where wheat is grown on the same soils as those under discussion in Russia, it would not seem to be a factor of current importance, and for the present it may be neglected.

AMERICAN GEOGRAPHICAL SOCIETY

The March Meeting. The regular monthly meeting of the American Geographical Society was held on March 21, 1933, at the Engineering Societies' Building, 29 West 39th Street, Vice-President Henry in the chair. Mr. Earl Hanson delivered a lecture entitled "The Amazon and the Andes Today: A Region of Social Regression." Mr. Hanson had shortly returned from eighteen months of travel in the interior of Venezuela, Colombia, Brazil, and Peru reoccupying the magnetic stations of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington and establishing new stations. He dealt particularly with the life of white men under tropical conditions as observed by him on his journey of thousands of miles by river craft, pack train, and airplane.

The April Meeting. The regular monthly meeting of the Society was held on April 25, 1933, at the Engineering Societies' Building, 29 West 39th Street, President Finley in the chair. Dr. Hellmut de Terra spoke on "The Yale North India Expedition." The expedition was in the field from March 1, 1932, until the middle of January, 1933, carrying out work in the Salt Range of the Panjab, in Kashmir, and in the High Himalayas and Eastern Karakoram. Its important results, which include a survey of 4600 square miles of heretofore unmapped territory, will be published in a forthcoming number of the *Geographical Review*.

Elections of Fellows. At the March and April meetings of the Society, there were presented with the approval of the Council the names of 14 candidates who were duly elected as Fellows of the Society.

Return of a Peary Arctic Record. A piece of an American flag that Admiral Peary left in a cairn on the shores of the Arctic Sea in 1906 was returned on Saturday, May 6, 1933, to his daughter, Mrs. Edward Stafford, the former Marie Ahnighito Peary. The presentation was made at the house of the American Geographical Society, Broadway at 156th Street, by Mr. Philip W. Henry, Vice-President and Chairman of the Council, at a luncheon tendered to Mrs. Stafford by the Society, at which also were present Dr. Isaiah Bowman, Director of the Society, and Mr. W. L. G. Joerg, in charge of polar research. Admiral Peary was President of the Society at the time he made the sledge trip in 1906 on which this record was deposited. The circumstances connected with the deposit and recovery were dealt with in Mr. Henry's remarks as follows:

"We have gathered together, Mrs. Stafford, for the purpose of restoring to your mother and yourself the memento left by your father at the most advanced point reached on one of his memorable Arctic journeys.

"You know under what conditions that journey was undertaken. He had just returned from his second attempt on the North Pole, on which he had been forced to turn back in latitude 87° 6′. Granting himself only a week's respite after those three months of arduous sledging over the drifting and hummocky ice of the polar pack, he started out in June, 1906, from his base at Cape Sheridan on the shores of the Arctic Sea. In rapid marches he followed the northern coast of Grant Land westward and proceeded beyond Cape Alfred Ernest, the farthest point attained in 1876 by Lieutenant Aldrich of the British Arctic expedition under Sir George Nares. Thence he outlined the coast to its end in a headland that he named Cape

Colgate, crossed the intervening strait, and set foot on the northern point (which he called Cape Thomas Hubbard) of a new island that he had first sighted in 1898 from the heights of the Ellesmere Island ice cap. This island was later explored by Captain Sverdrup of the second Norwegian Arctic expedition, who, coming from the south, reached Cape Thomas Hubbard and Cape Colgate in 1902. No one, however, has since visited the coast between Cape Alfred Ernest and Cape Colgate, the description of which by your father remains our only source of information.

"At Cape Thomas Hubbard on June 28, 1906, Admiral (then Commander) Peary had erected a cairn and left a piece of the American flag that he always carried with him. Late in May, 1914, Commander Donald B. MacMillan, on the return from his search for Crocker Land, passed by way of the cape and found this evidence of his predecessor's journey. Later it was turned over to the American Geographical Society as one of the institutions that had encouraged the Crocker Land Expedition.

"It gives me much satisfaction to return this relic to you now on behalf of the Society. What the flag of which this is a small fragment has meant in the life of your family is perhaps not generally known. Fashioned by your mother's hand, it was carried by your father, wrapped around his body, on all his expeditions. With it you yourself, the "Snow Baby," were covered when first taken out of doors after your birth in Greenland. And with it was mantled the casket that bore your father's remains to Arlington. Small sections cut from its folds were left by your father at the most advanced points of his Arctic journeys—at Cape Morris Jesup, the northernmost land of the earth; at Cape Columbia, the apex of the Arctic Archipelago; at Cape Thomas Hubbard; and at 87° 6′ and at the North Pole. Of the three pieces possible of recovery two have been found. That left at Cape Morris Jesup has recently been returned to you by Dr. Lauge Koch, the Danish geologist and Arctic explorer. It seems peculiarly appropriate that the section left by your father at Cape Thomas Hubbard is returned to you herewith by the American Geographical Society, the institution of which he was president at the time of that journey."

On receiving the memento Mrs. Stafford responded as follows:

"Mr. Henry, your friendly and understanding remarks, together with the gracious act of the Society in presenting this memento to my mother and me, have stirred me deeply. Every one versed in the customs of exploring expeditions knows that all records and relics brought back belong by courtesy to the organization or individual which has made the expedition possible. Your Society might so easily have placed this piece of flag among your records; instead of which you have given it to the two who will treasure it more than any others possibly could, and we thank you from our hearts.

"I doubt if anyone of you here, friendly and interested as I know you all to be, can understand just what this bit of flag means to me. It is not simply a glamorous piece of silk, home at last after years of wandering and adventure. It is a symbol to me of the perseverance, the courage, the undaunted determination of a man who devoted the best twenty-five years of his life to securing for his country a prize for which the great nations of the world had struggled for centuries. Five pieces of the flag were left at five different points in my father's explorations, and not one was placed in its cairn until he had expended the last ounce of energy and endurance at his command. The airplane seems like magic, and breath-taking and incredible the courage of men like Byrd and Ellsworth and Wilkins, who trust their lives to its mechanical perfection; but it will always be a source of satisfaction to me that my father was able to beat the Arctic with the same weapons which had been used against it for so long without avail.

"This piece of flag is also a symbol to me of the devotion and courage of the woman who made it. I shall always feel that my father would not have been the first to reach the Pole had it not been for my mother. She could so easily have nagged and whined and said: 'Other women have their husbands with them, why shouldn't I?

We are only young once and we are wasting our youth in separation and poverty. Why do you feel that you are the man to do this thing, when so many other brave men have failed?' He would have gone, because he was a strong-willed man with the deep conviction that it was his mission in life to discover the North Pole for the United States. But in those moments of black depression which swept over him when his carefully laid plans went awry from some totally unpredictable disaster, he would have thought, 'After all, why do I think I am the man for this job?' and he would have come home defeated, for no man can succeed when his courage and self-confidence have been undermined at the start. Instead, each time he went north, mother sent him off with flying colors, her pride and belief in him shining in her face, and when you send a man off like that, he just can't fail.

"And last but not least, this piece of flag is a symbol to me of all that the American Geographical Society has meant to father: his friendships with Judge Daly and with Mr. Hurlbut, which were among the bright spots in his life; his pride and pleasure in being the president of your Society; and the unswerving loyalty which that Society has given him at all times. For these reasons, I am particularly grateful that you have chosen this way to commemorate my father's birthday, and I thank you again from the bottom of my heart."

Catalogue of Maps of Hispanic America. The Catalogue of Maps of Hispanic America on which the Society has been engaged for a number of years is now ready for distribution. The catalogue, which contains over 15,000 items selected from the map collections of the American Geographical Society, the New York Public Library, the Library of Congress, the library of the Pan American Union, and the libraries of Columbia, Yale, and Harvard universities, is published by countries in four volumes. The map lists for each country are introduced by an article on the cartography of the country, accompanied by a map showing the extent and character of existing surveys, and are divided into five sections: (I) Maps in Scientific Periodicals, (II) Maps in Books, (III) Sheet and Atlas Maps (Official Publications), (IV) Sheet and Atlas Maps (Unofficial Publications), (V) Historical Maps. Each volume of the catalogue contains a classified index of its contents.

GEOGRAPHICAL RECORD

NORTH AMERICA

The Climate of Death Valley. In announcing the creation of a national monument of 1,601,800 acres in Death Valley the Department of the Interior observes that "travel during midsummer is not recommended." High temperature is the outstanding climatic feature of the valley. It is well known that until displaced by a figure of 136° F. at Azizia, Tripoli (1922), Death Valley held the world's record for absolute maximum temperature with 134° F. The meteorological station of the valley, which has been in constant operation since 1911, is at Greenland Ranch, better known as Furnace Creek Ranch, an irrigated spot some hundred feet above the floor of the valley, where it is likely still higher temperatures would be registered. Extreme maxima of 120° F. or higher have occurred every month from May to September inclusive; July averages 10 days with such temperatures; and in July and August, 1917, there were 43 consecutive days when this figure was attained or exceeded. Maxima of 85° F. have occurred every month of the year. Minimum temperatures of 90° F. or higher have been recorded from April to September inclusive. It is not true, however, that the valley is never cool. Temperatures of freezing or below have been recorded every month from October to March inclusive. The absolute minimum is 15° F. on January 8, 1913.

While lack of water has caused more fatalities than the heat, it is likewise not true that the valley is rainless. A rainless period of 401 days has been recorded from December, 1928, to January, 1930, but rain may fall in any month. The year's average is 1.38 inches; the greatest amount in any year (1913) is 4.54 inches; the greatest amount in 24 hours, 1.40 inches. Cloudy days are not uncommon, the average for the year being 71 (Ernest E. Eklund: Some Additional Facts About the Climate of Death Valley, Calif., *Monthly Weather Rev.*, Vol. 61, 1933, pp. 33–35).

Thermal Areas in the Atlantic Coastal Waters of the United States. In "A Geographic-Ecological Analysis of the Seasonal Changes in Temperature Conditions in Shallow Water Along the Atlantic Coast of the United States" (*Bull. of the Bingham Oceanographic Collection*, Vol. 4, Art. 3, 1933) A. E. Parr discusses the records of surface temperature taken between 1928 and 1930 inclusive at nineteen selected lightships and lighthouses scattered along the coast from Maine to the Dry Tortugas. South of Cape Cod the most important summer fisheries are found in this shallow water (10-fathom limit) which covers, roughly, an area estimated at 10,000 square miles.

Between Maine and the southern tip of Florida there are six well defined thermal areas. In three, the Gulf of Maine, the Cape Hatteras region, and the Straits of Florida, the annual range is comparatively small (homothermal). In the other three, Cape Cod and Nantucket Shoals region, the middle Atlantic, and south Atlantic sections, there is a rather large annual range (heterothermal). The middle Atlantic area has winter-time temperatures similar to those of the Gulf of Maine and summer-time temperatures almost equal to those of the southern area. Thus Cape Cod acts as a thermal barrier in the summer to the northward migrations of southern forms, and Cape Hatteras becomes equally effective in blocking the southward migration of the northern forms in the winter. This, in a large measure, accounts for the scarcity of permanent residents among the fishes in the middle Atlantic

section. The barriers are not permanent features at all seasons. Further, there is some possibility of a warm front or wall being formed during the cold season near Cape Canaveral which then prevents the northward migration of semitropical forms. Reasons are given showing why the winter invasion from the north to the middle Atlantic is quantitatively poor and not very penetrating, why the seasonal change in the composition of fauna in the middle Atlantic area is as complete as it is, and why there is such a high winter concentration of summer fish around Cape Hatteras. These are some of the ecological variations which result where homothermal and heterothermal areas are adjacent.

PHIL E. CHURCH

Malaria in the Southeastern United States. "Much of the inefficiency and comparative lack of energy attributed to the climate of the South may be laid with justice at the door of the so-called concealed diseases" is the conclusion of the chapter on "Climate, Health, and Energy" in Vance's "Human Geography of the South." Malaria is one of these diseases, and indirectly, if not directly, climate and also topography have a bearing on the matter. "Few of the communicable diseases are as peculiarly diseases of place as is malaria," say Mark F. Boyd and Gerald Ponton in "The Recent Distribution of Malaria in the Southeastern United States" (*Amer. Journ. of Tropical Medicine*, Vol. 13, 1933, pp. 143–166). Map and graph analysis of the distribution of malaria mortality and malaria infection reveals relatively great incidence in a zone extending from South Carolina into southeastern Alabama and central Florida. This zone is roughly coincident with a limestone belt characterized by "solution topography"—shallow basins and sink holes instead of the normal surface erosion channels. During wet summers water is retained in the basins thus providing favorable opportunities for the breeding of the anopheles mosquito. As a result malaria is intensified in years with rainy summers.

Cassia City of Rocks. In a basin of the Albion Range of southern Idaho lies the extraordinary assemblage of natural forms known as "Cassia City of Rocks." Turrets and fortresses, towers and spires, mosques and monoliths, human and animal shapes, natural bridges and caves, "bathtub" rocks, hollow boulders, and the like are carved from the granite outcrops. Nothing in North America matches this strange city, and Dr. Alfred L. Anderson, who describes it (Geology and Mineral Resources of Eastern Cassia County, Idaho, *Idaho Bur. of Mines and Geol. Bull. No. 14*, Moscow, Idaho, 1931) suggests that it even surpasses the fantastic Buffalo Rocks of Victoria, Australia. Cassia City of Rocks must have been a familiar sight to pioneer travelers—the old immigrant road to California passes about a mile to the south—and it is well worth the attention of tourists. The Old Oregon Trail (U. S. Highway No. 30), now the main arterial road across southern Idaho, is within 40 miles to the north.

Dr. Anderson ascribes the formation of the rock city to "a complex set of factors involving deep granular disintegration and case-hardening under especially favorable climatic conditions, together with especially favorable structural features, not alone the widely spaced sets of vertical and horizontal joints, but also the protective quartzite capping on the upper side of the basin and the flanking ridge on the lower side which has maintained a proper balance between erosion and weathering by not permitting too rapid removal of the waste products such as would have occurred had erosion not been retarded by the more resistant rocks."

New Edition of the George Washington Atlas. "The George Washington Atlas" (see *Geogr. Rev.*, Vol. 22, 1932, p. 502), in which are included reproductions of maps and plans made by Washington together with modern maps illustrating events in his life and places associated with or named after him, has been thoroughly revised

and republished in a smaller format (quarto) in "History of the George Washington Bicentennial Celebration" (United States George Washington Bicentennial Commission, Washington, D. C., 1932, Literature Series, Vol. 1, pp. 371–444). In spite of their reduced size some of the reproductions are clearer than those of the folio edition. Additions and minor changes in points of detail have been made on several of the modern maps, notably in the matter of Washington's routes. The list of Washington's maps includes 53 items discovered since the publication of the folio edition. Colonel Lawrence Martin, the editor, writes (April, 1933) that he has subsequently found six more, bringing the total to 170.

EUROPE

The Evolution of the Hungarian Alföld and Its Settlement. Travelers who visited Hungary in the middle of the nineteenth century, for example John Paget, the author of "Hungary and Transylvania," 1839, were greatly impressed by the *puszta*, as the treeless almost uninhabited waste of the Alföld was then known. Not only travelers but scientists, such as the botanists, Kitaibel and Kerner, assumed that the Alföld, with its area of approximately 100,000 square kilometers, was a "natural steppe," similar in origin to the steppes of southern Russia. The discovery on the Alföld of a few species of characteristic steppe vegetation seemed to offer proof of this assumption. However, through the microscopic examinations conducted by the botanist Rapaics and others it was discovered that the Alföld was originally a great forest. In spite of some extravagances in his "Ős Mátra Theory," Borbas demonstrated not only that the Alföld was a densely wooded tract in prehistoric times but also that its flora was identical with that of the mountainous regions of central and western Europe rather than with that of the Russian steppes. This conclusion is now generally accepted. It is assumed by De Soó and others that the species characteristic of steppe vegetation were introduced into the Alföld at the time of the great folk wanderings prior to the Magyar invasion of 896 A. D. (R. de Soó: A magyar puszta fejlődéstörténetének problémája, *Földrajzi Közlemények*, Vol. 59, 1931, pp. 1–15, English summary, pp. 44–46; the same: Die Vegetation und die Entstehung der Ungarischen Puszta, *Journ. of Ecology*, Vol. 17, 1929, pp. 329–350).

Scientists are not agreed, however, regarding the process by which the forested Alföld became a treeless steppe. The three factors—soil, climate, and man—are all involved. Foreign students tend to attribute the deforestation largely to the character of the soil, taken in conjunction with an increasing dryness of climate. The Hungarian scientists, however, assume that man alone is responsible for the condition of the Alföld in the middle of the nineteenth century. From Roman times until after the Tartar invasion in 1241 the work of deforestation went on. Belated attempts to preserve hunting tracts in the Middle Ages were unsuccessful. In support of this view, De Soó points out that in spite of the general deforestation some remnants of the old forest remain, such as that of Debreczen. Rungaldier seeks to synthesize the two viewpoints (Die Puszta Hortobágy und die Frage der Pusztenbildung in Ungarn, *Geogr. Zeitschr.*, Vol. 34, 1928, pp. 401–411). Deforestation would not have taken place without man's wasteful economy. Yet the character of both soil and climate was such that the steppe condition naturally followed the cutting of the trees.

Until the middle of the nineteenth century the Alföld was not only treeless: it was largely a marshy waste. Under the direction of Vásárhelyi the basin was drained. It was supposed that the reclaimed marshes would be the "granary of Europe," as partisans of the drainage scheme asserted. Although certain parts of the Alföld have provided excellent yields of grain ever since the reclamation, other parts have been completely ruined. In the latter the reclaimed marshes have become a waste

of alkali, which appears to increase in area yearly. De Soó has attempted to divide the Alföld into districts on the basis of character of soil (see also Otto Stocker: Ungarische Steppenprobleme, *Die Naturwissenschaften*, Vol. 17, 1929, pp. 189–196 and 208–213). Each type of soil obviously requires a different kind of treatment.

Settlement in the Alföld began on sand dunes just above the maximum line of inundation. Such location provided for the needs of water and defense and food, which was obtained in large part from the rivers and swamps. Schilling shows how two such "shoestring" settlements arose in the sandy region between the Danube and Tisza (Adalékok az Alföld földrajzához, *Földrajzi Közlemények*, Vol. 59, 1931, pp. 109–134; French summary, pp. 160–164). One row was placed as close to the Danube as the yearly inundations would allow. The other row was along the line where the inundated area was bordered by higher land.

Ruined village sites scattered over the Alföld give proof that in the pre-Turkish period, i.e., before 1526, the Alföld was densely populated. Practically every available site secure from inundation had been occupied. The Turkish régime led to the utter destruction of all the smaller communes on the Alföld. To escape wandering bands of *spahis*, the village people fled to the market towns and walled cities in which protection might be secured. The territory formerly belonging to the abandoned communes came into the possession of these "peasant cities." Thus Debreczen has now within its borders the territory of from 11 to 30 abandoned communes: Hódmezővásárhely received the territory of 22. Whatever agriculture had developed on the Alföld prior to the Turkish régime, though probably inconsiderable, was abandoned. The uncertainty of life and the great abandoned areas stimulated the development of the pastoral economy, which flourished until the second half of the nineteenth century.

Since the establishment of greater security and of reclamation by drainage, there has been a movement back to the land from the crowded peasant cities. The new settlers on the abandoned territory do not build up the old ruined communes. They settle rather on isolated farms or in scattered clusters of farms. These new settlements are known as *tanyak*, and the repopulation of the Alföld by this pioneer type of settlement is known as the *Tanyarendszer* (Kiss István: A Magyar Tanyai Közigazgatás, Budapest, 1932; Gesztelyi Nagy László: Magyar Tanya, Kalocsa, 1928; Szabó István: A debreceni tanyarendszer kialakulása, *Föld és Ember*, Vol. 9, 1929, pp. 214–244). It has already attained great significance. According to the Hungarian census of 1920 about a fifth—20.5 per cent—of the total population of the country lived on these tanya settlements on the Alföld. The census of 1930 showed that an even larger percentage—21.8 per cent out of the total population of 8,683,740—lived on the *tanyák*.

E. D. Beynon

The Szörénység: A Regional Study. The Szörénység, a part of the territory ceded by Hungary to Rumania by the Treaty of the Trianon, according to Ferenc Fodor is a well-defined region, or *táj*, similar to the French *pays du nom* (A Szörénység tájrajza, *Gazdaság-Földrajzi Gyüjtemény*, No. 6, Budapest, 1930). The Szörénység forms with its mountains a connecting link between the Carpathians and the Balkans and with its valleys offers a way of communication between the Hungarian Alföld and the plains of Rumania. In spite of this transitional character Fodor contends that physically it has always been definitely marked off from the surrounding areas and that changes in neither population nor administration have effaced this regional entity. Prior to the Turkish occupation the valleys were peopled by Slavs and Magyars, while Rumanian shepherd folk had trekked into the upland pastures. During the Turkish régime the valleys were depopulated and remnants of the Slavs and Magyars were assimilated by the Rumanians of the uplands. After the expulsion of the Turks, the Rumanians moved down into the valleys, the result being a

complete change in the racial elements making up the population. Hence the effect of the Turkish occupation was quite different on the Szörénység from that on the Alföld (see note above).

According to Fodor, the administrative boundaries of the region harmonized for centuries with the geographical boundaries. From the time of the Magyar invasion until 1880, with the single interval of the period of Turkish occupation, the Szörénység constituted a single administrative unit. Gyula Prinz (*Földrajzi Közlemények*, Vol. 59, 1931, pp. 27–29) criticizes Fodor's main thesis at this point. He holds that the regional character of the Szörénység is due not to physical but rather to political factors.

In 1880 the new county of Szörény was united with that of Krassó to form Krassó-Szörény County. The Szörénység lost its identity through a division into four districts under the economic dominance of Karánsebes (Rumanian, Caransebes). Although Karánsebes had a population of only 7988 persons in 1910, it had been the capital of the county of Szörény and remained, after the fusion of Szörény and Krassó counties, a corporate city. It is located at the intersection of lines of travel and communication between the Alföld, Transylvania, and Rumania. Even in Roman days Tibiscum, a *castrum* on this site, became a *municipium* and dominated the region. Although Karánsebes lies at the northwest corner of the region, it is the chief market town with which the entire region is integrated. According to Fodor, this economic dependence is expressed in three spheres of influence: an immediate zone, from which travel is by foot to Karánsebes; a median zone, from which travel is by horseback or by carriage to Karánsebes; and a "cultural zone," from which persons do not travel directly to Karánsebes but to smaller market towns which are themselves dominated by Karánsebes. This corresponds to the delimitation of zones made in recent American studies of metropolitan regionalism: Fodor's second and third zones of Karánsebes correspond to the metropolitan and trade areas of a city. At the time when this study of the Szörénység was made—1912 to 1922—Fodor considered that the 99 communes of the region were closely integrated as an ecological entity under the economic dominance of Karánsebes.

E. D. Beynon

The Aerial Survey of Hungary. Before the World War the Austro-Hungarian Empire had a highly efficient topographical survey. The 1:75,000 "Spezialkarte" was one of the most elaborate among the one-colored and hachured military maps of its time, and the colored 1:200,000 "Generalkarte" of Central Europe and the Balkan peninsula was a very creditable achievement of the Military Geographical Institute in Vienna. After the collapse of the dual monarchy the Institute remained in Austria, and the new states had to organize their own topographical surveys independently. The topographical work in Poland has been recorded already in the *Geographical Review* (W. L. G. Joerg: The Development of Polish Cartography Since the World War, *Geogr. Rev.*, Vol. 23, 1933, pp. 122–129). Remarkable work has also been accomplished by the other new nations.

In Hungary the task was not easy. However, preliminary studies revealed that the application of airplane photography provided enough saving in cost so that making a new survey was not beyond the limits set by the much curtailed budget of the Hungarian government. A new cartographic institute (Magyar Királyi Állami Térképészet) was organized in Budapest under the able leadership of Aurelius Medvey, and at the present time the work is well advanced (see Aurel Medvey: Das topographische Kartenwesen Ungarns, *Mitt. des Reichsamts für Landesaufnahme*, Vol. 8, 1932–33, pp. 99–114).

Sixty per cent of Hungary is lowland, but with rather confusing detail. It exhibits a maze of channels of exceedingly meandering old river beds; large tracts are covered with sand dunes; and the forms of land utilization also have resulted in a complicated

pattern. It is the kind of region where airplane photography can be applied with the greatest advantage.

The lowlands were photographed with a single-lens camera taking vertical pictures. The old trigonometrical stations were resurveyed and marked conspicuously with whitewash, and new stations were fixed so that there should be a measured point every 3 to 4 kilometers. The aerial photographs are taken from a 3200-meter flying height, with a Zeiss F-21 centimeter camera, producing about 1:15,000 pictures. The correction for tilt or varying heights of the airplane is done by the Aschenbacher semi-automatic rectifier, with the help of which correctly scaled prints can be made, upon which, in addition, a grid system is printed. The adjustment of the pictures in the transformator is done with at least three trigonometrically determined points. Blueprints made of these prints are taken back into the field by a ground party for adding altitudes, place names, and other information. About 1000 square kilometers are mapped yearly by this process.

The other 40 per cent of Hungary is hilly, in places mountainous. In these regions the aerial surveying is done with stereographic pairs and a stereoplanigraph. The flying altitude is somewhat lower, 2100 meters, to obtain 1:10,000-scale pictures. Instead of the more usual method of vertical photographs, the picture pairs are taken with converging axes, so that the overlap is 90 to 95 per cent. This method requires fewer trigonometrically determined points, fewer picture pairs have to be adjusted into the stereoplanigraph, and the greater length of the principal line gives greater accuracy than with the vertical pictures, where the useful overlap is only about 50 per cent. The Bauersfeld-Zeiss stereoplanigraph enables the operator to draw contour lines at close intervals (5 or 2.5 meters), and a wonderfully detailed and exact representation of relief can thus be obtained. A pair of pictures contains about four square kilometers of usable area, requiring several days to work out, so that the efficiency of this instrument is rather limited. A further limitation is that in forested areas the leading of the floating pin by the operator is difficult, and these areas have to be photographed in winter or early spring. About 300 square miles are done yearly with one instrument.

From the transformed photographs are drafted the 1:25,000 topographic sheets of Hungary. This map is rich in detail, as it utilizes the great amount of information supplied by the photographs. It is printed in five colors by offset lithography. The completed series will comprise 414 sheets, of which 115 are published already (1932). The new colored 1:75,000 series corresponds to the old Spezialkarte and will have 125 sheets, of which about 30 are ready. Twenty-two sheets of the 1:50,000 special maps have been prepared for tourist and general use. A new edition of the Hungarian part of the 1:200,000 Generalkarte and of the 1:750,000 map of Europe is also in progress.

ERWIN RAISZ

AFRICA

The Birunga Volcanic Field in Uganda. Where Uganda, Ruanda, and the Belgian Congo meet is the volcanic field of Birunga, better known as the Mufumbiro Mountains. About a tenth of its 1500 square miles, the northeastern part, is in Uganda, and this is the subject of a recent monograph (A. D. Combe and W. C. Simmons: The Geology of the Volcanic Area of Bufumbira, South-West Uganda, *Geol. Survey of Uganda Memoir No. 3, Part 1*, Entebbe, 1933). The area includes three of the great cones. Muhavura (13,547 feet), which from certain aspects presents a highly symmetrical cone, is built up of successive lava flows, in part extremely ashy, and layers of cinders and has a lake of 40 yards' diameter on its summit. The bare east and north faces are ravined, but the crater rim is not breached, and the subsidiary cones at the foot show little erosion. Mgahinga (11,400 feet) seems to have been active at a later date. The cone of Sabinyo (11,960 feet), much older and in fact the oldest volcano of the Birungas, is dissected by "spectacular" gorges. There are

no less than 34 smaller volcanoes that discharged lava and numerous crater hills, mostly explosion vents. Volcanism has also contributed to the scenery of the area by the lakes, such as Bunyonyi and Mutanda, which owe their origin to the damming of normal erosion valleys by lava.

From the economic standpoint, as Mr. Wayland points out in the preface to the volume, the region is interesting because the lavas "provide one of the largest leucite-bearing areas (and therefore perhaps one of the largest potash reserves) in the world, while in the north of the area covered by the map is part of the impenetrable forest of Lubugule, the home of the gorilla in Uganda, wherein have been found promising prospects of gold."

From the human standpoint the area is interesting by reason of the dense population it supports. There are more than 40,000 natives in the British part of the Birunga field, and all the arable land appears to be under cultivation, the steep slopes of the minor volcanoes being terraced for this purpose.

Coalfields of the Ruhuhu Basin, Southwestern Tanganyika. Discovery of exploitable coalfields would be a great advantage to the railways of East Africa, which at present must import all their coal from Natal. Coal-bearing strata of the Karroo formation are known to exist in the southwestern part of Tanganyika Territory. In his 1929 report on preliminary surveys for a railway line to open up this part of the Territory, C. Gillman (see also Brigadier E. M. Jack: Railway Development in Tanganyika Territory, *Geogr. Journ.*, Vol. 79, 1932, pp. 117–124) advocated an investigation of the mineral resources. A preliminary survey has now been made of the country of the lower and middle Ruhuhu, east of Lake Nyasa (Report on the Geology of the Ruhuhu Coalfields, *Tanganyika Geol. Survey Bull. No. 2*, Dar es Salaam, 1931). Here 1330 square miles of Karroo formation is downfaulted in an area of ancient rocks. Seven coalfields were recognized, four of which would seem to have economic possibilities. The most promising are those of Ngaka, along the southern border of which passes the disused motor road from Songea to Manda or Lake Nyasa, and the Ketewaka-Mohuchuma field, which lies off the main routes but could be connected by motor road with Manda. Vast deposits of iron ore lie some 20 to 50 miles north of the latter field.

The coal is a noncoking bituminous type with possibilities as a steam coal. It is suggested that, in view of the high ash content of a large proportion of the coal and the wide potential radius of distribution, the production of fuel oil would be the most practicable method of exploitation. The region has a sufficiency of timber and is well watered; labor is fairly plentiful, but all European foodstuffs and other supplies would have to be brought in. The so-called "East Route" for a railway in southern Tanganyika would pass through the coal area.

The Colonization of Kenya. In the southwestern quarter of Kenya Colony two plateaus, separated from each other by the eastern of the two rift valleys of East Africa, reach a maximum altitude of 13,000 feet. The relatively cool, moist climate and fertile volcanic soils on the plateaus have attracted British settlers even though the region lies directly under the equator. A railroad connecting the coast at Mombasa with the Victoria Nyanza gives access to the outer world. European settlement of the plateaus dates back only thirty years. White settlers (17,285 in number in 1931) are a mere handful compared with an estimated native population of over three million. There are more than twice as many Asiatics—mostly Hindus—as there are Europeans, and two-thirds as many Arabs. In 1929 the number of European landowners was only 2035; 2882 heads of families were dependent for their living on agriculture. The problems of settlement in Kenya are the subject of a recent monograph by Ernst Weigt (Die Kolonisation Kenias, *Mitt. Gesell. für Erdkunde zu Leipzig*, 1930–1931, Vol. 51, 1932, pp. 25–123). His discussion, which

is illustrated by an excellent series of maps, is the more valuable in that it presents a non-British point of view not unduly, if at all, colored by anti-British sentiment.

Attempts made shortly after the war to establish demobilized soldiers on the land met with little success. The settlers "were not pioneers, who pushed into the interior on their own responsibility; they were not small folk, and they were seldom farmers accustomed to work with their hands. Called in by the government, they were attracted by the prospect of readily acquiring large estates and by the promise of cheap and sufficient labor." A good deal of capital is required and "a caste of great proprietors" has come into being and gained possession of much of the best land. For the native population extensive reserves have been set aside. Many natives, either at their own free will or by force of economic pressure, have come forth from the reserves and settled as squatters on the great estates and on unappropriated crown lands. The squatter problem is one of many difficulties with which the white settlers have to contend.

Another is the difficulty of obtaining labor. This seems something of a paradox in a country where the natives so vastly outnumber the settlers. Native reluctance to serve the whites has been met by the imposition of hut taxes, poll taxes, etc. Petty Hindu merchants, however, penetrate the reservations and by trading with the natives have often made it possible for the latter to raise sufficient cash to meet tax payments and other obligations without having to work for the colonists. This is only one among several causes of friction between the Indians and the British. Weigt concludes that Kenya, far from becoming a "White man's country," has remained essentially "a colony of economic development and exploitation (Wirtschaftskolonie)."

The Benguela Railroad and the Projected Line to Walvis Bay. In 1931, after many difficulties, the Benguela Railway was completed and linked by a short Belgian line to the Cape-to-Cairo line at Tenke (H.F. Varian: The Geography of the Benguella Railway, *Geogr. Journ.*, Vol. 78, 1931, pp. 497–523). Already its monopoly of the shorter, swifter export route from the copper fields of the Congo-Zambezi watershed is being threatened by a proposed extension of the Walvis Bay Railway across the Kalahari to join the Cape-to-Cairo line south of Livingstone. *The African World* (April 30, May 7, and May 14, 1932) has published a summary of the official reports—reconnaissance, geological, and agricultural—of the Walvis Bay-Rhodesia Survey, and their findings have been more recently discussed in an article by C. F. Rey, "Ngamiland and the Kalahari," in the October, 1932, *Geographical Journal*.

Distance and gradients are the decisive elements determining the ultimate route by which the copper of Rhodesia and Katanga will reach the seaboard. From Ndola, on the frontier of the British and Belgian fields, it is 1511 miles via Tenke to Lobito Bay, 1448 miles via Bulawayo to Beira, and 1524 miles via Matetsi, between Livingstone and Wankie, to Walvis Bay. The distance to Lobito Bay may be shortened by building a cut-off south of Katanga through Rhodesian territory to Kanshanshi. That to Beira may be greatly shortened by building a line across from Salisbury through Sinoia to Lusaka, the new capital of Northern Rhodesia. The proposed Walvis Bay route must remain in point of distance the longest, yet over Beira it has the advantage of serving Atlantic instead of Indian Ocean shipping, while over both Beira and Lobito Bay it has the advantage of a more level roadbed. From Matetsi toward Walvis Bay the ruling grade for the first 520 miles would be 1 in 240. Beyond Gobabis, the present railhead, the grade is about 1 in 40. From Matetsi toward Beira, on the other hand, the ruling grade for the first 520 miles is 1 in 61, later becoming 1 in 39. The grades on the Benguela line in piercing the coast ranges are so steep that at Lengue Gorge it has been necessary to construct a mountain-rack section. Since these irregularities in gradient approximately balance whatever advantage in length the existing Benguela or Beira routes have over the proposed Walvis Bay route, all three may be considered as fairly equal competitors.

As terminal points Lobito Bay and Walvis Bay have replaced, respectively, Benguela and Swakopmund. The two bays are formed by a phenomenon frequent enough on the west coast of Africa wherever the Benguela Current is felt. Sand spits, more than a mile long and capable of protecting ships at anchor or against the quay, have been built up by the action of the current. When the present writer visited Lobito Bay in 1929, en route to the inauguration of the Benguela Railway to the Belgian Katanga frontier, few harbor works had yet been undertaken. At present, however, Lobito Bay is one of the best-equipped ports between Casablanca and Cape Town. Walvis Bay, metamorphosed in 1919 from a mere British enclave into the principal shipping point of a vast hinterland, is fitted with electric cranes, a concrete wharf, and a cold-storage and refrigerating plant.

The main difficulty of the Rhodesia-Walvis Bay route lies in the water supply, and one of the principal tasks of the party making the preliminary survey was the charting of existing waterholes in the Kalahari and the analysis of geological formations that may promise water when drilled. This party, after traversing 14,796 miles by lorry, selected a route leading eastward from Gobabis to Sandfontein, on the frontier of Southwest Africa and Bechuanaland, thence northeast to Eersterust in the Ghanzi area, thence to the Botletle River, and from the Botletle River to Matetsi, a total distance of 594 miles. A few years ago the plateau between Gobabis and Sandfontein was waterless; today the Angola Boers, who came into the region when they were allotted farms here in 1928, have found water wherever they have bored deep enough.

As regards water generally, Mr. A. M. MacGregor, the geologist, says: "Very little of the water which falls in this region escapes by the Orange, Limpopo, or Zambesi rivers into the ocean. The major portion evaporates within the area. . . . What is left soaks down towards the lowest parts of the basin . . . there need be no fear that ample supplies of water will not be found anywhere in the sand of the low-lying region" (*The African World*, Vol. 119, 1932, p. 81). In other parts of the region the supply will depend on the form of the floor upon which the sand rests and on the depth of the sand. "In the Ghanzi district water is proved to be plentiful in wells under 40 ft. or less of sand. Between that district and the Botletle river the only outcrops of bed rock are the peaks of ancient hills which give no information regarding the form of the floor around them. If the floor is deep, the sand may be expected to yield water at a depth not exceeding 200 ft. If the floor is shallow, however, the water may be restricted to certain buried valleys. The same doubt applies to the tract of country between the Rhodesian border and the Makarikari depression."

As a matter of practical railroading it is important along both the Benguela and the Walvis Bay-Rhodesia routes that settlers should establish themselves whose importations from Europe or America and whose shipments of foodstuffs to the mines can provide an in-going traffic to balance the out-going traffic in ores. The possibilities for settlement along the Benguela Railway in Angola are great. Already we have a response to the line in such developments as that of Huambo, now known as Nova Lisboa, the new summer capital of Angola. As regards the Walvis Bay line Dr. A. E. Romyn, who made the agricultural survey says that generally speaking "the semi-arid nature of the country and the character of the soil practically limit the possibilities of most of the area to stock-raising, supplemented by the cultivation of relatively small areas of drought-resistant fodder crops" (p. 114). Ranching on the "sweet veld" between Eersterust and Rakops and on the less-favored regions elsewhere on the Walvis Bay-Rhodesia route can accommodate some 1,700,000 head of cattle. "If a policy of extensive settlement is followed, a 75-mile strip on either side of the line promises within some twenty years a possible annual production of 170,000 head of cattle, 1,500,000 pounds of butter fat, and 30,000 sheep."

Auxiliary lines serving the main routes can be built from the Benguela Railway

toward the Musonoi tin region, toward the Kanshanshi copper region, and toward the diamond fields of the Kasai. A line may be built out from the Walvis Bay-Rhodesia route to connect directly with Plumtree and Bulawayo, while it is even possible that from Gobabis southwards a short line may be built into the great tract of nitrate of soda, the discovery of which was announced in July, 1929, by Professor Smeath of Cape Town University.

WILLIAM LEON SMYSER

ASIA

A Rural Economic Survey of Siam. The economic survey has reached "Lotus Land" and subjected the "Asian Arcady" to the questionnaire in the form of a commission under Carle C. Zimmerman of Harvard University to investigate conditions of rural life in Siam (Siam: Rural Economic Survey, 1930–1931, Bangkok, 1931). The chapter entitled "Regional Problems" conveniently sums up the findings from a geographical angle. The country was divided into four major regions—northern, northeastern, southern, and central (compare the more refined subdivision of W. Credner: Grundzüge einer Gliederung Siams in seine Teillandschaften, *Geogr. Zeitschr.*, Vol. 36, 1930, pp. 193–211; 273–292; and note especially in relation to Credner's geomorphological and vegetation maps). All of Siam is underpopulated with the exception of the circle of Bangkok and its vicinity, where nearly a fifth of the population of the country lives on a fiftieth of the total area. In northern Siam less land is under cultivation than in former times. Not only is good land not in use but in some districts only one crop is raised where there is capacity for two. "Water and Siamese agriculture are inseparable," and more water is needed for irrigation. With the exception of the southern peninsula the total annual rainfall is not great. In the northeastern region the basin-like Korat plateau is characterized by a "very wet wet-season and a very dry dry-season" (compare monthly rainfall maps in "Siam: Nature and Industry," Ministry of Commerce and Communications, Bangkok, 1930). There are consequent limitations on the production of upland rice, and the raising of other cash crops—cotton, tobacco, and silk—is suggested. The large areas of swamp lands should be surveyed for the establishment of property rights, and flood control is needed on the Mekong, which forms the eastern boundary of Siam.

Underpopulation is very evident in southern or peninsular Siam. Associated with the unsatisfactory water supply is the prevalence of yaws; malaria also is a serious problem here, as it is in the north. Formerly the copra industry flourished in the south; it lost to tin mining and rubber growing and now "tin and rubber prices are down and the coconut trees are gone." A more productive coconut palm is needed and the importance of a second-crop agriculture "cannot be stressed too much"—beans and peanuts, perhaps, in combination with rice.

Central Siam is well past the self-sufficing agricultural stage. Rice, of course, is the great commercial crop. Water shortage is general—the rainfall during the rice-growing season is only about 40 inches—and the use of oil pumps on the individual farms is advocated among the measures for improving farm technique. Two sections of the central area call for special comment. The hilly country of the southeast, Chandaburi, is largely unsuitable for rice cultivation. Pepper, long a staple, has declined in value: control of the fungus disease and coöperative marketing are advocated. Fruit growing is already prosecuted as far as is economically advisable under present conditions, and there is no alternative opportunity: "The pepper industry should be saved or some of the people should be moved away and colonized."

On the land irrigated by the Rangsit Canal are the largest farms and most rice land per family, but economic and cultural conditions are the poorest. Farmers are in debt to the Chinese merchant and the Siamese landlord, and improvements

are prohibited by the mobility of the population—tenant farmers brought haphazard from all over the country.

The Merapi District of Central Java. Although Merapi is not one of the highest, it is unquestionably one of the most active and dangerous of Java's numerous volcanic cones. The eruptive phenomena exhibited by this volcano closely resemble those that caused the terrible disaster on the island of Martinique in the year 1902 (compare "A Volcanic Eruption of the Pelée Type: Merapi, 1930," *Geogr. Rev.*, Vol. 22, 1932, pp. 327–328). Merapi and Merbaboe, to the north, may be considered as twin volcanoes located, with others, on a line of weakness running about north and south. On this fault line the manifestations of volcanic activity have, according to Kemmerling, migrated southward and Merapi, the last volcano in the alignment, is considered the youngest. Its efflata predominate in the surrounding regions, almost completely covering the deposits of the neighboring older volcanoes. On all sides except to the north, where the volcano merges with its neighbor, Merbaboe, the foot of the Merapi slopes down very gently, occupying a considerable territory. The entire region, embracing parts of Kedoe, Djokjakarta, and Soerakarta, is important both for native and estate agriculture (L. van Vuuren: De Merapi: Bijdrage tot de sociaal geographische kennis van dit vulkanisch gebied, *Geogr. en Geol. Mededeelingen, Rijksuniversiteit te Utrecht, Anthropo-geogr. reeks No. 2*, Utrecht, 1932).

In Kedoe no European plantations exist, while in the other two districts, which are only indirectly controlled by the government of the Dutch East Indies, large areas have been leased by the native rulers to western capital. In the lowest parts of the plains, where soils are heavy and where there is a rather sudden transition from the wet to the dry season, lie the cane-sugar estates with their factories. Higher up, where rainfall is somewhat more evenly distributed, one finds tobacco plantations, also entirely in the hands of Europeans. Still higher, on the east slopes of Merapi, lie a few coffee and tea gardens. In Kedoe the rice fields of the natives reach to nearly 3000 feet. Below 1500 feet the *sawahs* (wet rice fields) are interspersed with numerous native tobacco plantings.

Throughout the region there exists an intimate relation between the density of population and the distribution of volcanic soils. Densities are highest in the districts where the fine Merapi efflata prevail, and lowest where the Tertiary is exposed. However, regardless of local fluctuations, the density of population everywhere is extremely high, generally from 1000 to over 1500 to the square mile.

Such extraordinary densities, partly an immediate consequence of the "pax neerlandica," have led not only to the occupation of practically all the available land but have also necessitated a nearly continuous use of the land with a minimum of two crops per year. Rice is the most important single product but yields remain considerably below those of more advanced countries. On the non-irrigable lands "ladang rice" (dry rice) has in recent years been replaced by crops that give a higher yield per acre, as corn and cassava. These crops are also produced on the *sawahs* during the dry season. The natives are turning more and more to the cultivation of commercial crops, such as tobacco and peanuts, for the world market, but their income is nevertheless still exceedingly low.

WILLIAM VAN ROYEN

THE POLAR REGIONS

Explorations in East Greenland South of Scoresby Sound. While Dr. Rasmussen's Seventh Thule Expedition was carrying out its intensive study of the Greenland coast from Cape Farewell to Angmagssalik (compare pp. 385–393), another Danish expedition was making a record in another difficult stretch of the East Greenland coast. In 1932 Captain Ejnar Mikkelsen took the first ship from Cape Dalton,

south of Scoresby Sound, to Kangerdlugsuak, north of Angmagssalik (Ejnar Mikkelsen: The Blosseville Coast of East Greenland, *Geogr. Journ.*, Vol. 81, 1933, pp. 385–403). It was not, however, his first trip along this coast, for he was a member of Amdrup's 1899–1900 expedition and accompanied him on the rowboat and sledge journey that gave the first definite information of the Blosseville Coast. The prime object of Captain Mikkelsen's 1932 voyage was the study of the suitability of the coast for Eskimo occupation—a continuation of his earlier work that resulted in the establishment of the thriving settlement at Scoresby Sound (Ejnar Mikkelsen: The Colonization of Eastern Greenland: Eskimo Settlement on Scoresby Sound, *Geogr. Rev.*, Vol. 17, 1927, pp. 207–225).

Along the Blosseville Coast the land fringe is narrow; there are none of the "great valleys covered in vegetation, and the smooth mountain slopes, which are seen from Scoresby Sound towards the North": large land mammals cannot secure food and the scattered and patchy nature of suitable ground likewise limits the smaller mammals—foxes, hares, etc. On the contrary, bird life proved richer than had been expected, and, as seals were abundant, bears were plentiful; the life of the fiords and ocean was indeed rich, especially about Kangerdlugsuak and the neighboring Mikis Fiord. An important scientific contribution was the recognition of a zoölogical and botanical boundary about Cape Ravn dividing the dry, cold, central-arctic climate from the warmer, moister North Atlantic climate. The characteristic distinction between the inner fiord climate and the outer coast climate also obtains. It is particularly in evidence in the Kangerdlugsuak area where a difference in rock formations—gabbro-basalt of the coast and nepheline syenite of the interior—affects the biota. Investigations of the nepheline syenite discovered by L. Wager of Watkins' expedition in 1930, was continued by Mr. Wager, who was acting as geologist on Mikkelsen's expedition. Another Englishman, Michael Spender, was in charge of the cartographic work. This embraced a rapid coastal survey for a revision of Amdrup's map and a detailed photogrammetric survey of Kangerdlugsuak, revising work of Watkins' expedition.

On his return trip from Angmagssalik to Julianehaab in 1931 Rasmussen had been shortly followed by members of Watkins' party making their "Open-boat Journey" (see Captain Lemon's narrative in "Northern Lights: The Official Account of the British Arctic Air-Route Expedition, 1930–1931," by F. Spencer Chapman, London, 1932). A part of the southeastern coast was also covered by a Norwegian scientific and hunting expedition whose activities are described by the scientific leader, Thorolf Vogt (Norges Svalbard- og Ishavs-undersøkelsers ekspedisjon til Sydøstgrønland med "Heimen" sommeren 1931, *Norsk Geogr. Tidsskrift*, Vol. 4, 1933, pp. 289–325). The expedition worked between Tingmiarmiut and Umivik, centering on Skjoldungen Island and its fiords. Dronning Maria Valley, six to seven miles long and covered with high bush of dwarf birch and willows, is warm and beautiful; berries are abundant and there are still plenty of salmon, 50 to 80 centimeters long, in the stream of this "Salmon-place." The scenery of the south arm of the fiord is magnificent with its 1000-meter-high walls. Old Eskimo winter houses, mostly overgrown, are numerous. Two of special interest lay so low that the sea at flood washed the ruins, indicating, says Vogt, recent subsidence of the land, possibly due to growth of the glaciers during the last few thousand years. Small glaciers in this fiord and at Umivik show recent recession. Mikkelsen also had an impression of general retreat of the glaciers on the Blosseville Coast. He expressly mentions the phenomenon between Cape Rink and Cape Normann, where large glaciers that he had seen 32 years previously had disappeared. Southeastern Greenland was again visited in 1932 by an expedition of the Norges Svalbard- og Ishavs-undersøkelser: this was under Dr. Gunnar Horn on the *Veslemari*.

All these expeditions remark the numerous traces of ancient Eskimo occupation of the East Greenland coast. When and how was it populated? The earlier studies

of the Angmagssalik Eskimo favored the view that migration took place round the north coast; the present tendency is toward an opposite view. Dr. Therkel Mathiassen spent 1931–1932 in Angmagssalik making archeological and ethnological investigations (Prehistory of the Angmagssalik Eskimos, *Meddelelser om Grønland*, Vol. 92, No. 4, 1933). He thinks there is scarcely any doubt that the earliest culture in Angmagssalik originated from the West Greenland Inugsuk culture by migration round Cape Farewell, most probably in the latter part of the fourteenth century. In the course of the sixteenth, seventeenth, and early eighteenth centuries the material culture received new forms from West Greenland, partly by slow infiltration, partly by direct migration. The small rectangular house was an early introduction. It has spread along the entire east coast and is the prevailing form in the northeast. Only in the extreme north is the house form influenced by the round house of Cape York. Possibly the rectangular form derives from the influence of the Norse occupation. The large rectangular house suggests new immigration about 1700. During the course of the nineteenth century, the Angmagssalik culture acquired its distinctive local development. At the end of the century modern West Greenland semicivilization made its entry and "in the face of all this the ancient culture gave way, slowly but surely; its fate was sealed."

Bathymetry of the Arctic Sea North of Spitsbergen. Although the *Nautilus* could not carry out her original plan of under-ice investigations (see *Geogr. Rev.*, Vol. 22, 1932, pp. 156–157) she was able to secure important oceanographical data by taking advantage of the extraordinarily favorable ice conditions of 1931 and penetrating farther north (81° 59′ N.) than any previous expedition from Spitsbergen by ship. Parts I to III of the scientific results appear in the *Papers in Physical Oceanography and Meteorology* published by the Massachusetts Institute of Technology and Woods Hole Oceanographic Institution (Vol. 2, No. 1, 1933).

Dr. H. U. Sverdrup discusses the series of oceanographical observations "which throw light on some of the problems relating to the currents in the Polar Sea" and Floyd M. Soule discusses the echo-sounding. The latter's report is accompanied by a bathymetrical map compiled from 256 sonic soundings taken by the *Nautilus* combined with other available soundings. The salient feature of the map "is the general configuration of the Spitsbergen-Greenland ridge. It seems that the main ridge extends from the Greenland peninsula of Northeast Foreland in a direction about N. 60° E. into the Polar Sea north of West Spitsbergen, while a second ridge whose axis is nearly perpendicular to the first connects it with the northwestern part of Spitsbergen, thus completing the threshold between the Polar and Greenland seas. A valley communicating with the depths of the Polar Sea is thus formed north of West Spitsbergen between it and the extension of the first-mentioned ridge. The continental shelf extending northward from Northeast Land for 70 or 80 miles rapidly drops to oceanic depths near the mouth of this valley. The soundings of the *Nautilus* are not extended far enough to the northwest to give definite information as to the saddle depth of the Spitsbergen-Greenland ridge. When Nansen first conjectured the existence of this ridge, which now ought to bear his name, he supposed the saddle depth to be 700 or 800 meters, but later on he arrived at the result that the saddle depth probably was deeper and lying between 1100 and 1500 meters." Dr. Sverdrup's conclusion supports the latter view.

PHYSICAL GEOGRAPHY

Meteorite Scars. How many scars does the earth's surface bear as the result of bombardment by meteorites in recent time? Within the last few years several undoubted "meteorite craters" have been described, and there is a growing tendency to suggest a meteoritic origin for anomalous depressions in many parts of the world.

L. J. Spencer discusses the present status of the subject in a recent well-illustrated article (Meteorite Craters as Topographical Features on the Earth's Surface, *Geogr. Journ.*, Vol. 81, 1933, pp. 227–248). He lists five examples of meteorite craters for which the evidence is fairly conclusive. Two of the examples are single, isolated pits, and three consist of groups that appear to record swarms of meteorites.

Meteor Crater, Arizona (formerly known as Coon Butte), is much larger and deeper than any of the other well-established examples; its average diameter is about three-fourths of a mile, and it is 570 feet deep. At Henbury, Australia, the largest of several craters is 660 feet long, 360 feet wide, and 50 to 60 feet deep (A. R. Alderman: The Meteorite Craters at Henbury, Central Australia, *Mineralogical Mag.*, Vol. 23, 1932, pp. 19–32). A pit in Ector County, Texas, has an average diameter of 530 feet and a depth of about 18 feet (E. H. Sellards: Unusual Structural Feature in the Plains Region of Texas, *Bull. Geol. Soc. of America*, Vol. 38, 1927, p. 149). Of two craters recently discovered at Wabar, Arabia, the larger is about 325 feet across and 40 feet deep (H. St. John Philby: Rub'al Khali, etc., *Geogr. Journ.*, Vol. 81, 1933, pp. 12–14). In northern Argentina there is a group of peculiar small depressions. The largest of these, occupied by a lake, is about 245 feet long and about 212 feet wide; the largest dry pit is 183 feet in diameter and 17 feet deep (Juan José Nágera: Los hoyos del Campo del Cielo y el meteorito, *Direcc. Gen. de Minas, Geol. e Hidrol., Publ. No. 19*, Buenos Aires, 1926).

The examples listed above are remarkably alike in several respects. All the pits are rimmed by broad embankments that rise distinctly above the surrounding plains. At all the localities pieces of meteoritic iron have been found closely associated with the craters. The bottoms of several depressions reveal disturbed strata, and in at least two—the Arizona and Texas examples—the strata dip rather steeply outward from the center. Material forming the rims can generally be determined as débris thrown out from the pits. At all the localities except that in Texas, masses of glass are found in the débris; and this glass from the pits of Arabia and Arizona is known to be fused quartz sand, indicating an extremely high temperature locally. Most of the pits are nearly circular, although exceptions are found in Australia and Argentina.

The common evidence gives strong support to the theory of meteoritic origin. Probably all the impacts were attended by explosions, caused by partial vaporization of the materials involved. Discussion of this point by Harold Jeffreys and others is printed with Spencer's paper.

A similar origin has been attributed to several other features for which the evidence is not as yet convincing. These include a group of small craters on the Baltic island of Oesel; numerous pits in Siberia, presumably formed in 1908, when a terrific explosion leveled the surrounding forests and caused meteorologic disturbances recorded in distant countries; a curious depression near Gwarkuh in Persia; and the Ashanti crater containing Lake Bosumtwi in West Africa. The last-named depression is several miles in diameter and several hundred feet deep. Its elevated rim is formed of bed rock and not of débris (Malcolm Maclaren: Lake Bosumtwi, Ashanti, *Geogr. Journ.*, Vol. 78, 1931, pp. 270–276).

Shortly before Spencer's paper appeared, a meteoritic origin was suggested for a large group of shallow depressions in North and South Carolina (F. A. Melton and William Schriever: The Carolina "Bays"—Are They Meteorite Scars? *Journ. of Geol.*, Vol. 41, 1933, pp. 52–66). Most of these features so far reported lie in low ground near the coast. They are strongly oval in plan, and they range in length up to 8090 feet. The rims, formed of loose sand, are wide and only a few feet high; the interiors are occupied by nearly level swamps, beneath which peaty deposits extend to a depth of 20 feet or more. Some of the bays intersect, and the rims of some are tangent to each other. The long axes of all are remarkably parallel, although the bays are scattered over an area of several hundred square miles. The bays and their relationships are shown exceptionally well by aerial photographs.

Melton and Schriever consider several hypotheses of origin, but conclude that all features of the bays are explained only by assuming a large shower of meteorites that fell obliquely from the northwest. No direct evidence of such a shower has yet been found. The authors plan a geophysical survey in an attempt to locate meteoritic material.

The reviewer, in company with R. F. Flint and E. I. Leith, has made a rapid field examination of the area in which the bays occur. We agree that the features described by Melton and Schriever are remarkable, and that their formation by ordinary geologic processes seems improbable. C. Wythe Cooke suggests (personal communication) that they are coastal features, formed in lagoons under the control of onshore winds. Any hypothesis must take into account not only the bays near the present coast but also a considerable number of shallow, oval pits scattered over higher areas of the coastal plain, some of them at least 65 miles from the present shore line. Because of the nearly circular plan of most recognized meteor craters, the strongly oval form common to all the Carolina "bays" may be urged as unfavorable to the Melton-Schriever hypothesis.

The problem of dating some of the meteorite craters is receiving considerable attention. D. M. Barringer in 1905 speculated that Meteor Crater, Arizona, is only 2000 or 3000 years old. Blackwelder concludes that a much greater age must be assigned to this pit (Eliot Blackwelder: The Age of Meteor Crater, *Science*, No. 1981, Vol. 76, 1932, Dec. 16, pp. 557–560). He bases his conclusion partly on the effects of weathering and erosion in the vicinity of the crater, but in important measure also on the presence of thick lake deposits on the bottom of the pit, which show that at some time after the depression was formed the region had a much more humid climate than at present. Included in the deposits is a layer of volcanic ash, which he thinks probably dates back to the Pleistocene epoch. Blackwelder suggests that the crater was formed during the last interglacial stage, "perhaps 40,000 to 75,000 years ago." F. Martin Brown (*Science*, No. 1992, Vol. 77, 1933, Mar. 3, pp. 239–240) discounts some of the evidence used by Blackwelder in concluding that the crater has considerable antiquity. He refers to the recently discovered evidence of an ash fall that occurred about 793 A.D. at a locality "not too distant from the Meteor Crater." This, it may be pointed out, is Sunset Crater, described by Harold S. Colton in the October, 1932, number of the *Geographical Review*.

CHESTER R. LONGWELL

The Variation of Rainfall. It is not an easy matter to agree upon a fixed method for determining the reliability of rainfall: the best procedure depends largely upon the particular problem in hand and upon the geographical situation of the area in question. In "Rainfall Reliability in Australia" (*Proc. Linnean Soc. of New South Wales*, Vol. 57, 1932, pp. 95–100) Mr. J. A. Andrews departs from the customary method of employing the arithmetical mean of the annual rainfall in favor of the most frequent annual amounts.

The "mode," or value that occurs most frequently, was determined for a large number of stations in Australia and an isohyetal (10-inch isohyets) map constructed in which the mode is expressed as a percentage of the total number of years of record. The results obtained seem to be in fair agreement with maps based upon average departures from the normal annual rainfall in the wet southwest and the dry northwest, but the agreement is poor for the interior and the east. On the whole there seems to be considerable uniformity in reliability over the Australian continent, the greater part of the area showing values between 30 per cent and 50 per cent of the normal. This result is not in harmony with the generally accepted opinion. However, there is still considerable uncertainty about rainfall conditions over a large portion of central Australia.

Whereas the average rainfall is a definite amount easily determined, the mode

is the middle point of a band, the limits of which must vary with the particular end in view. This Mr. P. R. Crowe points out in describing the method he employs in "The Analysis of Rainfall Probability: A Graphical Method and Its Application to European Data" (*Scottish Geogr. Mag.*, Vol. 49, 1933, pp. 73–91). "The best way to appreciate the innate variability of rainfall is to plot the actual monthly totals year by year . . . Alternatively, the years may be superimposed to show the scattering of the records as in the Atlas of American Agriculture." To this atlas Mr. Crowe acknowledges his indebtedness for the initial idea of a dispersion diagram. Its graphs, however, are based upon the method of departures from the arithmetical mean monthly rainfall: he adapts them to the method of departures from the "median" monthly values. Additional critical points also are located, namely the lower and upper "quartiles," or the values most nearly one quarter and three quarters along the rank. The difference between the quartiles represents the range covered by the most centrally placed half of the values and as such is regarded as a good measure of mean dispersion. Half this amount is known as the quartile deviation, and the variability for a given month is expressed as a percentage of some mean value. A better idea of the frequency of more extreme values may be developed by indicating the position of the outer "octiles," located midway between the quartiles and the extreme readings from the top and bottom. Among refinements of method is the grouping of monthly values by some simple form of moving average, the smoothed figures are freed to a large extent from change variation and emphasize seasonal pulsations. When we think in terms of two or three monthly rainfall values the real significance of variations is brought out.

Other methods for defining rainfall probability have been used with satisfactory results. Dr. Gustav Hellmann, the well known German climatologist, based his investigations of rainfall probability in central Europe on the ratio between the extremes of annual rainfall; in his scale a ratio of 2.0 or less, or a maximum equal to or less than two times the minimum annual rainfall was regarded as very favorable, a ratio of 2.0 to 2.4 favorable, 2.5 to 2.9 fairly so, 3.0 to 3.9 unfavorable, 4.0 to 4.9 very unfavorable. One great advantage of this method of ratios of maximum to minimum annual amounts is that a fairly fixed ratio may be obtained from comparatively short records. Application of the method was recently made by the present writer in a study of rainfall stability in the United States. Complete records by states for the 50-year period from 1881 to 1930 were employed. In the case of 26 states out of the total of 48 the length of the period between the wettest and the driest years ranged from 2 years to 9 years; the average length of this period was only 12 years, and in only 6 states was the length of record required to establish the ratio greater than 30 years.

OLIVER L. FASSIG

Microclimatology. Studies of local climatic differences, particularly in the air rather close to the ground, have been increasingly occupying the attention of meteorologists interested in the practical aspects of the subject. In a general review of microclimatology in *Die Naturwissenschaften* (Vol. 21, 1933, pp. 132–137), Dr. Rudolf Geiger describes the development of this phase of climatology. The German botanist, Gregor Kraus, was the first to publish (in 1911) investigations of microclimate with measuring instruments which established quantitatively the relation of microclimate to plant life. Meteorologists became interested and in recent years have established a satisfactory technique for measuring the considerable differences that may be found in vertical distances of only a few centimeters. Dr. Geiger in 1927 published the first book on microclimatology from the meteorological standpoint, "Das Klima der bodennahen Luftschicht."

The importance to plant life of the climatic features of the air near the ground is much greater than is usually realized. Discussing the physics of the layer of air

within one and a half or two meters of the ground, Geiger points out that the climates of the bottom and top may differ as much as some continental versus marine locations a thousand miles apart. In an area studied by Geiger near Munich, frosts occurred on half the days in June, and the temperature fell to −8.8° C., while there was no frost at Munich, in fact the minimum was 8.2° C. So frequent were the frosts that the area in question was treeless; and around the edges or in other frost pockets pine trees, though thirty years old, stand only knee-high. Where frost has not prevented trees from getting started the forest creates its own climate. The air temperatures within the forest are much like those in the upper layers of the ground. The tops of the trees constitute the true surface of the earth in a meteorological sense. This has been investigated in great detail recently in both oak and oak-and-beech stands, recording instruments being exposed at six heights within the forest and at one a little above the crowns of the trees. In the oak forest the air temperature in the crowns of the trees was 2° C. higher by day than near the ground and 1° warmer in the evening. In the oak-and-beech stand at midday the air about the crowns was 6° C. warmer than the lower air and 3° warmer than the free air four meters above. In the evening the crowns were still 2° warmer than the lower air, but 1° cooler than the free air (see *Forstwissenschaftliches Centralblatt*, Vol. 54, 1932, pp. 371–383).

Damaging frost and methods of protection are summarized in Geiger's book. Of the 81 references to literature, 57 are to American studies. The critical discussion of the whole subject and particularly the summary of European studies of the frost problem should be particularly valuable to the American student of frost.

The section of the Köppen-Geiger "Handbuch der Klimatologie" entitled "Mikroklima und Pflanzenklima" (Vol. 1, Part D, 1930) includes a brief summary of the physics of the subject and a helpful description of the methods of observing microclimate—methods which obviously must be quite different from those ordinarily employed in climatology. Many new studies have been made, for example those by Geiger showing temperature unrest—changes of several degrees in as many minutes—and by W. Schmidt on wind structure. Dr. Schmidt's motion pictures of small pressure-plate anemometers indicate a surprising degree of gustiness and turbulence close to the ground.

The importance of microclimate to man is discussed briefly from an agricultural and a physiological standpoint. In the latter connection the warmth of cities is presented very clearly by the automobile-surveying method. In quiet weather the centers of cities may be 8° C. or more warmer than the wooded or low countryside near by. Meteorological automobiles and bicycles are being employed in many cities to determine the distributions of temperature, humidity, sunshine, and blueness of the sky. In Vienna on a hot day the temperatures in narrow streets were found to be 6° C. cooler than those of the open boulevards. Striking distributions of temperature and fog have been reported from some American cities where for several years occasional microclimatic studies have been made by set stations or by the automobile-surveying method. Hanns Tollner has recently published a summary of this city-surveying activity (*Sitzungsber. Akad. der Wiss. in Wien, Math.-naturw. Klasse*, Abt. IIa, Vol. 141, 1932, pp. 1–13).

To complete the study of the climatic environment of man, meteorologists are now taking close account of the climate indoors. The interest in the physiological aspects of climate bids fair to improve the climatic environment of man, which in recent years has been made worse by human agencies that have appreciably modified city climates. Geiger points out in his latest paper that man can now pick a microclimate that approaches what he wants, say for sanatoriums, and can then by skilful building improve the climate to suit his needs. The possibilities in this line are only beginning to be appreciated.

CHARLES F. BROOKS

HUMAN GEOGRAPHY

A New Series of Studies of Latin American Cultures. Professors H. E. Bolton, A. L. Kroeber, and C. O. Sauer are the editors of a new collection of monographic studies entitled *Ibero-Americana* (University of California Press, 1932, 1933). The studies are "in Latin American cultures, native and transplanted, pre-European, colonial, and modern. Physical and racial backgrounds have a place in the collection, but it is anticipated that the studies will be in the main contributions to culture history." Four numbers have appeared.

The first number of the series, "Aztatlán: Prehistoric Mexican Frontier on the Pacific Coast," by Carl Sauer and Donald Brand, is based largely on observations made during the winter and spring of 1930 in the coastal belt of Sinaloa and Nayarit. Archeological exploration and geographical fieldwork were combined in what the authors call an "archaeogeographic reconnaissance." In the finished monograph physiographic, ecologic, and climatologic data are skillfully integrated with archeological and historical evidence.

Aztatlán is the oldest name known to have been applied to the area studied—a long, narrow strip between the rugged barrier of the Sierra Madre of Durango and the sea. A people of relatively advanced culture dwelt here at peace before the Spaniards came, but Nuño de Guzman ravaged their country in 1530–1531 and killed off most of the inhabitants or sold them into slavery.

Aztatlán is connected with the Pueblo country of Arizona and New Mexico by a great natural corridor, a belt of structural depressions paralleling the Gulf of California and carrying far to the south the "basin and range" topography characteristic of much of the southwest of the United States. One might expect that this corridor would have formed a more or less homogeneous cultural area with marked affinities between the peoples at its southern and northern ends. Sauer and Brand found no evidence of this. Immediately north of Aztatlán the corridor was occupied by the Cahitas, a more primitive people with a different type of culture.

Indian trails, however, passed through the whole length of the corridor, and over them flowed some little trade in pre-Spanish days. Turquoise was carried southward, and the brightly colored plumage of tropical birds was brought north in exchange. During the second and third quarters of the sixteenth century these trails were followed by Spanish explorers in their search for the legendary Seven Cities of Cíbola (the Zuñi pueblos). In "The Road to Cíbola" (*Ibero-Americana*, No. 3) Carl Sauer reconstructs the northward routes of Francisco Cortés, Nuño de Guzman, Fray Marcos, Coronado, and Francisco de Ibarra along this great natural avenue, and the southward march of Cabeza de Vaca by the same track. "One expedition retraced the steps of the others." In correlating the confusing details given in the Spanish records with the topography Sauer has the advantage of first-hand knowledge of the country, something that earlier students of these explorations have lacked. After the period of exploration, "the road to Cíbola became the camino real of the northwestern frontier, the great artery of the entire region."

Ibero-Americana, No. 2, by R. L. Beals, is entitled "The Comparative Ethnology of Northern Mexico Before 1750." It deals with a wide region that has long been more or less *terra incognita* to the anthropologists. In this region, however, must be sought the clue to whatever connections may have existed between the two more highly developed cultures on each side, the Pueblo cultures of the Southwest of the United States and the Aztec, Maya, and related civilizations of southern Mexico. Beals's study is based primarily on early Spanish sources. By means of maps and tables the recorded occurrences of many different cultural traits are analyzed and a tentative division made of northern Mexico into culture provinces. The concept of northern Mexico as a "debatable ground, a region in which the Southwestern culture area shades into the Mexican culture area" is shown to be misleading. The

greatest differences within the region are between the agricultural peoples of the Sierra Madre and west coast and of Tamaulipas on the one hand, and the non-agricultural nomads of the plateaus, on the other. Only the agricultural peoples were closely related to the southern Mexicans, and it is among them—not among the nomads—that must be sought "the solution to the problem of connections and transmissions between southern Mexico and the United States."

Ibero-Americana, No. 4, by Paul S. Taylor, deals with "A Spanish-Mexican Peasant Community, Arandas in Jalisco, Mexico." From this isolated community of unusually pure Spanish stock many emigrants have gone to the United States. Taylor is also the author of "Mexican Labor in the United States," consisting of several monographic studies concerning Mexicans in different regions in this country (*Univ. of California Publs. in Economics*, Vols. 6 and 7, Berkeley, 1928–1932).

Population and Censuses of 1790 and Earlier. Two important studies of the early population of the colonies and the United States have recently appeared. Evarts B. Greene and Virginia D. Harrington have gathered together from widely scattered sources all the available figures for the period before 1790 (American Population Before the Federal Census of 1790, Columbia University Press, New York, 1932). No attempt was made to interpret the figures. It "seemed best simply to provide the student with data from which he may draw his own inferences." Based on far more exhaustive research, the volume supersedes what has hitherto been the most authoritative treatment of the subject, the chapter on colonial population in "A Century of Population Growth," published in 1909 by the Bureau of the Census. The arrangement of the materials is clear and convenient. For the colonies as a whole and for each separate colony the results of general counts or estimates are presented in chronological order, and for each colony local tabulations by towns, counties, parishes, etc., are given separately. To the geographer these local tabulations seem to cry out for expression on maps. One cannot but think what a fine population atlas for the colonies could be made out of these figures, in spite of the difficulties its preparation would involve, for no two censuses are wholly comparable.

The other study pertains to the linguistic and national stocks in the population of the United States in 1790 and likewise supersedes the discussion of this subject in "A Century of Population Growth." It represents the results of an investigation made by a committee of the American Council of Learned Societies (*Ann. Rept. Amer. Hist. Assn. for the Year 1931*, Washington, 1932). The names of heads of families listed in the first census of the United States, 1790, supplied the principal criteria. Certain names were selected as being distinctive of different linguistic or national stocks—such names as *Hall* (English), *Robertson* (Scotch), *Murphy* (Irish), *Schneider* (German). It was assumed that "the occurrence of names distinctive of a mother country in a population largely drawn from that country measures roughly the proportion of the population coming from that source." On this basis a complex statistical analysis was made and carefully checked against historical and genealogical evidence. The final results for the United States as a whole may be summarized as follows: out of a total white population of 3,226,944 persons, 1,939,396 (60.1 per cent) were assigned to English stock, 261,138 (8.1) to Scotch, 190,662 (5.9) to Ulster, 116,248 (3.6) to Irish, from what is now the Irish Free State, 279,220 (8.6) to German, 100,000 (3.1) to Dutch, 73,750 (2.3) to French, 21,100 (0.7) to Swedish, and 25,625 (0.8) to Spanish; 219,805 (6.8) could not be assigned. Perhaps the most unexpected outcome of the study concerns New England, where it was found that "the scant measures of leading English names in a population heretofore supposed to have been well over 90 per cent English are striking and perplexing." This is particularly true of northern New England.

For other parts of the world than America, A. B. Wolfe gives a brief survey of "Population Censuses Before 1790" in the *Journal of the American Statistical Asso-*

ciation (Vol. 27, 1932, pp. 357–370). Without attempting to compare or estimate populations on the basis of these early censuses, he points out where and when censuses have been taken and gives useful bibliographical references. It appears that "the Biblical account of the Lord's wrath at the taking of [David's] census remained an argument against census taking even as late as the eighteenth century." In spite of this, some unusually comprehensive counts were made in Italy during the late Renaissance.

GEOGRAPHICAL NEWS

A Chair of Geography in the Library of Congress. A chair in geography has been created at the Library of Congress under a trust fund established by the late James Benjamin Wilbur of Manchester, Vt. The function of the chair will be research directed towards the perfecting and interpreting of the Library's collections. The first incumbent is Colonel Lawrence Martin, chief of the Division of Maps of the Library of Congress and a contributing editor of the *Geographical Review*.

OBITUARY

H. R. H. Luigi Amedeo of Savoy, Duke of the Abruzzi. With the death in Somaliland on March 18, 1933, of H. R. H. Luigi of Savoy, Duke of the Abruzzi, a distinguished figure is lost to geography. Writing recently in the *Geographical Review* (Vol. 21, 1931, p. 65) Giotto Dainelli said: "We are now in a position safely to prophesy the economic future of Italian Somalia. That we may do so is almost exclusively to the credit of a Prince long recognized for the courage with which he has undertaken hazardous enterprises: H. R. H. Luigi di Savoia, Duke of the Abruzzi, climber of Mts. St. Elias and Ruwenzori, once holder of the world's records for having reached farthest north in the Arctic and the highest altitude in the Himalaya. By his personal initiative the Duke founded and has directed an extensive agricultural project, which has served to reveal the economic possibilities of Italian Somalia and to provide an example for other projects of the same sort."

The Duke had a naval career of eminence: his geographical activities began with his conquest of Mt. St. Elias in 1897, the first ascent of this 18,000-foot Alaskan peak. Two years later he embarked on a North Polar expedition. The expedition went into winter quarters on Crown Prince Rudolf Island, most northerly member of the Franz Josef Land group, whence a party under Captain Cagni reached 86° 34′ N. by sledge, surpassing Nansen's farther north and holding the record until Peary's effort of 1906. For his "successful achievements" and "shining example" on these two expeditions the Duke received, among other honors, the Cullum Gold Medal of the American Geographical Society. The "snowy summits of a chain, until within the last two decades shown only on the maps of ancient geographers" next attracted his attention, and in 1906 the chief peaks of the Ruwenzori massif were ascended and mapped. Three years later the Duke was in the Karakoram Himalaya and while the attack on K_2 failed, a near-by peak, Bride Peak, was climbed to a height of 7500 meters. The last expedition made by the Duke of the Abruzzi was to the sources of the Webi Shebeli in Abyssinia in 1928–1929 (Le sorgenti e il corso dell'Uebi Scebeli, *Boll. della R. Soc. Geogr. Italiana*, Ser. 6, Vol. 6, 1929, pp. 359–371), an undertaking made directly in relation to his pioneer settlement work on the lower river.

GEOGRAPHICAL REVIEWS

Palestine and the Mandate

George Adam Smith. **The Historical Geography of the Holy Land.** 25th edit., revised throughout; xxviii and 744 pp.; maps, indexes. Ray Long & Richard R. Smith, Inc., New York, 1932. $6.00. 9 x 6 inches.

Bonaventura Ubach. **El Gènesi.** xi and 315 pp.; maps, ills. (La Bíblia il·lustració pels monjos de Montserrat, XXIII-1.) Monestir de Montserrat, 1929. 11 x 8½ inches.

Edmond Fleg. **The Land of Promise.** Translated from the French by Louise Waterman Wise. With an Introduction by Ludwig Lewisohn. 256 pp.; map, ills. The Macaulay Company, New York, 1933. $2.00. 8½ x 6 inches.

Norman Bentwich. **A Wanderer in the Promised Land.** xi and 263 pp.; map, bibliogr., index. Charles Scribner's Sons, New York, 1933. $2.75. 8½ x 5½ inches.

Fannie Fern Andrews. **The Holy Land under Mandate.** Vol. 1, xvii and 361 pp.; Vol. 2, ix and 436 pp.; map, diagr., ills., bibliogr., index. Houghton Mifflin Company, Boston and New York, 1931. $10.00. 9 x 6½ inches.

Since the days when Moses led the children of Israel out of Egypt Palestine has exerted a baffling fascination over the minds and hearts of men. This strange country, with some of its surrounding lands, is dealt with from widely divergent points of view in these five books.

Sir George Adam Smith's classic and "La Bíblia" are addressed to Christian students of the Bible who, as Smith puts it, may wish "to see a background and to feel an atmosphere; to discover from 'the lie of the land' why the history [of Syria and Palestine] took certain lines and the prophecy and gospel were expressed in certain styles." In the new edition of "The Historical Geography of the Holy Land" there are no radical departures from the earlier editions, although changes have been made in points of detail. The results of recent discoveries in the fields of archeology, history, and philology have been drawn on, a new chapter on the Land of Edom has been added, and brief observations have been included on Allenby's campaign of 1917–1918 and on the present state of the country.

"La Bíblia" is an illustrated commentary on the Bible—or, more correctly, on the Book of Genesis, for the entire work is as yet incomplete. Every scriptural passage of any geographical or archeological interest or of significance from the point of view of folklore is elucidated by photographs, maps, and drawings. For example, the story of Lot's wife is illustrated by photographs of salt columns in the neighborhood of the Dead Sea. If it be true, as often stated, that the outward aspects of the land and the manners and customs of most of its people have altered but little since the days of Abraham, this excellent volume will help many a student "to see a background and to feel an atmosphere." One may enjoy and derive profit from the splendid pictures without a knowledge of the Catalan tongue in which the commentary is written.

Edmond Fleg and Norman Bentwich are Jews of high distinction. Their volumes reflect something of the appeal of Palestine to enlightened members of their race. Fleg is a Parisian, a writer of books and producer of plays. To him the appeal of Palestine is mainly to the heart. Bentwich writes in a less subjective vein. His

volume is presumably a work of leisure hours, the fruit of fifteen years' residence in Palestine. The author held a high administrative post under Allenby and later served as Attorney-general. Partly a record of wanderings through the country—wanderings that took him over nearly the whole of Palestine itself as well as to Aqaba, Petra, and far into Syria—the book consists, in the main, of a series of essays on the long and troubled history of the Jews in Palestine and on places and monuments hallowed by Jewish tradition.

Dr. Andrews' two large volumes are of a different character altogether. They provide an extremely detailed, impartial, and comprehensive study of the almost hopelessly complex problems to which the British fell heir in accepting the mandate. An introductory survey covers present-day life, the geographical and religious settings, and British personalities who have helped and are helping to shape the destinies of the Holy Land. Zionism before and after the famous Balfour Declaration is discussed at length. A full account is given of Arab life and organization, of Arab opposition to Jewish settlement, of the incidents at the Wailing Wall, of British policy and its critics, and of the international ramifications of these problems. The author often delves far back into history, and her book is thoroughly documented with references to and quotations from official reports, letters, and other contemporary sources.

It is both the glory and the tragedy of Palestine to be a land holy to the followers of three great faiths. Transcending the political and economic problems—which would be bitter enough in any event—is the eternal religious issue. Dr. Andrews makes clear the intensity of feeling with which shrines and other holy places are regarded and the conflicts that have arisen over their control and protection. The outstanding example is the famous Western or "Wailing" Wall of the Jewish Temple. The recurrent riots and disturbances that have occurred in recent years concerning the ceremonies at the wall have raised one of the most difficult of all the problems with which the British administration has had to contend, and even the League of Nations has been involved.

It is of interest to note that there is much less conflict between Mohammedan and Christian than there was under the Turkish régime. "To-day," writes Dr. Andrews, "we see both Moslems and Christians strongly united in one political aim. Differences in religion play little part in the pursuance of their desires; regardless of their religious affiliations, the Arabs are linked in an obstinate determination to hold on to the country which they have occupied for centuries and centuries." To the Jew, however, the country is the Promised Land, theirs by virtue of a tradition that goes back to the beginnings of history. The two concepts are irreconcilable, and Jew and Arab, "as recent events have proved, are farther apart to-day than at any time during the eleven years of the Mandate." Dr. Andrews concludes that "there is no way of even approximating the time when conditions may shape themselves favorable to independence. Neither is there any adequate criterion for presaging the form of independence which may ultimately develop from the Palestine Mandate."

The Congo Region

Maurice Robert. **Le Centre Africain: Le domaine minier et la cuvette congolaise.** 261 pp.; maps, diagr. Maurice Lamertin, Brussels, 1932. 9 x 6 inches.

"Le Centre Africain" is the Belgian Congo with the adjacent part of Northern Rhodesia, a region which, with scant half a century elapsed since its enshrouding veil was cast aside by Stanley, is now recognized as one of the world's most important repositories of natural wealth. M. Robert treats the region as two distinct zones, one dominated by mining, the other by agricultural possibilities. The mining zone is the highland area forming the eastern and southern watershed of the Congo system. The agricultural zone lies within the river basin.

Exploitation of mineral resources has been rapid—copper, tin, gold, diamonds, radium, cobalt, and coal. All are important in their potentialities, the copper of the Katanga region has played the chief rôle in the development thus far. Extending as an arc from the Bwana M'Kubwa section of Northern Rhodesia, across the southern part of Katanga province in the Congo, to a probable termination in the Northern Rhodesia-Angola frontier region lies a vast body of copper sulphides and oxidized ores. With proved reserves of about 25 million tons, and probable reserves of over 50 million tons, in ore assaying better than 4 per cent, this deposit could supply 200 to 300 thousand tons of refined copper annually for an indefinite period.

It was a natural sequence to mineral discoveries that the Katanga region should become a railroad center. From Elizabethville trunk lines extend southward 3865 kilometers to Cape Town; southeastward 2605 kilometers to Beira; northeastward, utilizing waterways of the Lualaba and Lake Tanganyika, 2797 kilometers to Dar-es-Salaam; northward over waterways and connecting rail lines of the Lualaba to Stanleyville, head of navigation on the Congo; northwestward, utilizing 825 kilometers of waterway on the Kasai, 2797 kilometers to Matadi; and westward 2107 kilometers to Lobito. All except the Dar-es-Salaam trackage is of the 1.067-meter standard South African gauge. M. Robert classes the Lobito and the Matadi lines as alone of primary importance. While granting the more privileged position to the Lobito line, he discusses the important part which the all-Belgian route to Matadi, with railroad substituted for the waterway section, could be made to play in copper transportation. Yet the economic considerations favoring the line across Angola would seem to outweigh political considerations for the other carrier. Not only does the Matadi route involve nearly 700 kilometers additional haulage, but its port does not compare with the excellent natural harbor at Lobito. In view of friendly relations that have existed between the Belgian Congo and Portuguese Angola as neighbors, Lobito's recently acquired position as the outlet for a considerable part of Katanga metal would not seem to be threatened.

M. Robert rates as of only secondary importance the Rhodesian connection to Beira, which had played a leading part in copper transportation before completion of the Lobito line. Even with the construction of the Salisbury-to-Kafwe cut-off connection, shortening the haulage distance about 800 kilometers on this route, there remain the handicaps of some 3000 miles of boat travel, a toll on the Suez Canal, and several weeks of transit to western European markets. However, artificial considerations in the form of long-term contracts with Northern Rhodesian producers, not mentioned by M. Robert, should preserve the Beira road's status as a copper carrier during the next decade. Eventually most of Northern Rhodesia's copper, aside from tonnages required to balance inbound shipments of South African goods, should find its outlet at Lobito as he suggests.

Just as development of the mineralized perimeter of the Congo region is founded on a system of railroad trunk lines, so are the industries of the basin established on a system of navigable waterways. Here railroad spurs are merely incidental, the means of passing falls and rapids. There are more than 10,000 kilometers of such waterways, operated regularly over some 24 routes. Slow, inexpensive transportation of this order is well adapted to the basin's produce, chiefly palm kernels, palm oil, copal, cotton, and wood—articles of heavy bulk but for the most part of low value.

The outlet for these products to world markets is discussed. For many years the rapids of the lower Congo, separating the river port of Kinshasa (Leopoldville) from the ocean steamer port of Matadi, had been the great obstacle to the colony's development. Reconstruction of an inadequate railroad connecting these ports, with advantageous relocation near Matadi made possible by recent interchange of territory between Belgium and Portugal, has helped to alleviate this condition. M. Robert would do even more, by electrifying these 373 kilometers of railroad through the use of near-by water energy. From the economist's viewpoint it is not clear how this further

undertaking might be justified. For M. Robert states that agricultural products can bear only a minimum share of railroad operating expenses, which leaves interest and amortization charges upon a considerable investment to be carried by mining products, the mass of which might more advantageously use a competing line. Furthermore, Matadi has serious disadvantages as a port because of the alluvial deposits that collect above the Congo's submerged estuary. Dredging is required to maintain the passage at a depth of 7.5 meters. When it is considered that erosion between Leopoldville and Matadi causes no less than 12 million cubic meters of alluvium to be deposited in the river's delta annually, the magnitude of any project of port improvement upon the estuary becomes apparent. Although mentioned but briefly in this work, the railroad in French territory from Brazzaville to Pointe Noire could, when completed, serve for the Congo's agricultural products just as the road in Portuguese territory is functioning for its metals.

Interesting data are given regarding water-power resources of the Congo. This river system, aggregating a minimum flow of 30,000 cubic meters a second, traverses a succession of peneplains separated by fractured zones at which occur abrupt changes in level. The resulting supplies of hydro-energy are well distributed throughout the watershed. Hydro-electric installations now operating in the Katanga region use but a small part of the power available. M. Robert's tabulation of more than a million horse-power reserves in this region is based on highly theoretical data, but he makes his point clear that there is sufficient water energy available at low installation costs to provide for needs of present and future industries, including electrification of railroads.

Most impressive of the power reserves is that of the lower Congo, where the entire flow falls through a height of 267 meters. M. Robert estimates 50,000,000 horse power as capable of development from this source, which is well in excess of the combined output of all hydro power installations in the world today and represents one ninth of the world's total reserves of water power.

W. E RUDOLPH

ORNITHOLOGICAL STUDIES IN CENTRAL AFRICA

JAMES P. CHAPIN. **The Birds of the Belgian Congo, Part I.** x and 756 pp.; maps, diagrs., ills., index. *Bull. Amer. Museum of Nat. Hist.*, Vol. 65, New York, 1932. 9½ x 6½ inches.

J. VINCENT. **The Namuli Mountains, Portuguese East Africa.** Map, ills. *Geogr. Journ.*, Vol. 81, 1933, pp. 314–332.

Dr. Chapin, who spent some eight years in the Congo during the period 1909 to 1931, has much to say of geographical interest in the first half of his volume, a section entitled "General Survey of the Country and its Bird Life."

It is at first glance a little surprising that the area dealt with is the political unit of the Belgian Congo rather than the physical unit of the Congo basin. Dr. Chapin found the political delimitation more suitable to his purposes. He preferred to leave out the regions east of Lakes Tanganyika and Bangwelo, because they have a fauna predominantly East African, and also the vast northwestern extension of the Congo basin reaching into Cameroon, because it had been fully treated by others. On the other hand he had a special object for wishing to include the western slope of the Ruwenzori Range, which drains to the Nile, for here the mountain forest and an extension of the great equatorial forest are connected at one point without intervening grasslands and provide exceptional opportunities for a study of bird life with relation to altitudes. After all, watershed barriers are relatively unimportant in Africa; seldom do they coincide with the principal mountain ranges, more often they are mere gradual transitions scarcely noted by the traveler as he crosses them.

To two points only can we call attention here. The first is the bearing of the

physical features on the development and distribution of mountain birds. There is the depression of the central Congo, dating back to the Triassic or earlier, with north and south bounding ranges of equal age which probably rose a thousand feet higher during the Tertiary. To its east lies the western lip of the Albertine Rift, the great trough that encloses Lakes Albert, Edward, Kivu, and Tanganyika—a ridge that, like the high Ruwenzori Range forming part of the Albertine's eastern escarpment, may have existed since the Eocene. Within the rift have arisen the Kivu volcanoes, probably not older than the Pleistocene, which blocked Kivu's outlet to Lake Edward and the Nile and added its waters to Tanganyika and the Congo.

The occurrence of some of the same species of mountain birds on Mt. Cameroon as on Ruwenzori and in East Africa, localities now separated by vast lowlands, presents an interesting problem. Dr. Chapin seeks a solution in an extension of the mountain forest during the Pleistocene when, as is well known, the Ruwenzori glaciers had a much greater extension and the vegetational zones were at correspondingly depressed altitudes. Later the lake that is believed to have formed in the Congo basin during the Pleistocene—not to be confused with the flooding of the Congo in the Triassic, which had no influence upon the present ranges of birds—may have acted as a partial barrier between the eastern and western sections of this forest. Underlying rock formations are not regarded by Dr. Chapin as of any great importance in affecting the distribution of lowland birds, those living up to 5000 feet elevation. Here one finds a thick layer of superficial soil, with the lowland forest covering sedimentary and crystalline rock formations alike.

Dr. Chapin describes the unique conditions that result from the location of the Congo's tributaries on both sides of the equator, the one set subject to the rainy season when the other set is dry. His map establishes times of year for the two periods of high water in the main river, but he barely mentions the regulatory effect which this balancing of flooded and dry feeders exerts upon the combined flow. Naturally an eleven-foot mean fluctuation in river level at Leopoldville would have been highly important to the bird scientist, because of its effects upon birds' habits. However, we should like to add that mean high water at this section of the river is only fifty per cent higher than mean low-water flow and that the highest flow of record is only double the lowest. Such even conditions of flow as occur in the lower Congo are truly extraordinary, and they may be counted on to facilitate the ultimate development of its vast water energy resources—the key to the possibility that the African continent may some day sustain a large civilized population.

Making ornithological investigations for the British Museum, Mr. J. Vincent discovered a physical barrier dividing certain East African and South African bird forms in a chain of island mountains crossing Quelimane, Mozambique. The outstanding peak of the chain, Namuli, rises from the surrounding country in the form of a figure eight, covering about 30 square miles above the 4000-foot contour. Two double-peaked domes rise as almost perpendicular masses of grayish-white granite from intermediate plateaus to above the 8000-foot level. The general cloud level upon the mountain lies at about 6000 feet, obscuring the peaks save upon rare occasions.

Mr. Vincent records the altitude of Namuli's main peak as 8850 feet and states that it is the highest mountain in Mozambique. This elevation checks closely with the 2700-meter elevation (8858 feet) tabulated in the *Anuário Estatístico* of Mozambique published by the Portuguese Government in 1932. However, the government publication mentions another peak of equal altitude in the Manica-Sofala territory and states that the highest elevation in the colony, 2950 meters (9678 feet), occurs in the district of Niassa.

At the 4400-foot level on the slopes of Namuli heavy forest replaces savana vegetation and exhibits an interesting and distinctive flora and fauna. Such forests are rare in Mozambique, for, whereas the maps show numerous island mountains of

sufficient altitude for forest growth, most of them are tooth-like crags without vegetation. The relatively high elevation of the Namuli massif has produced a local climate of abundant rainfall. Precipitation on the higher slopes is estimated at 110 to 120 inches with little evidence of the dry season that occurs from May to October throughout most of Mozambique.

Of the discovery of these mountains Mr. Vincent tells us that they were reported to the traveler O'Neill in 1882 but were not seen by him because of cloud masses and that they were explored by the scientist Last in 1886. Yet the existence of mountains at this location must have been known fully a quarter of a century earlier, for John Arrowsmith's map of South Africa dated 1857, showing the routes of David Livingstone between 1849 and 1856, indicates hills or mountains extending from longitude 37° 30′ E. to the Shire River, at about 15° 45′ S. Mr. Vincent's coördinates of 15° 20′ S. and 37° 04′ E. for Namuli prove the early location to have been not greatly in error.

W. E. RUDOLPH

EXPLORATION IN INNER ASIA

ROY CHAPMAN ANDREWS. **The New Conquest of Central Asia: A Narrative of the Explorations of the Central Asiatic Expeditions in Mongolia and China, 1921-1930; with chapters by Walter Granger, Clifford H. Pope, and Nels C. Nelson.** I and 678 pp.; maps, diagrs., ills., bibliogr., index. (Natural History of Central Asia, Vol. 1.) American Museum of Natural History, New York, 1932. $10.00. 11 x 9 inches.

SIR AUREL STEIN. **On Ancient Central-Asian Tracks: Brief Narrative of Three Expeditions in Innermost Asia and North-Western China.** xxiv and 342 pp.; map, ills., index. Macmillan & Co., Ltd., London, 1933. $10.00. 9½ x 7 inches.

These two volumes share the spell of that wide desert belt that transects the Old World and the romantic element it offers to scientific exploration—whether it be discovery of a skull of *Tritylodon*, mammal of the reptilian age, or of the hidden library of the Caves of the Thousand Buddhas; chipped flints of a Stone Age people of the Gobi or the wooden label from "the clothes bag of one called Lu Ting-shih" on a Chinese frontier wall of the first century of our era.

"The New Conquest of Central Asia" is an introduction to the scientific reports of the Central Asiatic Expeditions of the American Museum of Natural History, 1921–1930 (compare the review of Vol. 2, "Geology of Mongolia," *Geogr. Rev.*, Vol. 18, 1928, pp. 692–693). The bulk of the volume is a narrative by Roy Chapman Andrews, the leader, of the five seasons' work in Mongolia, the chief theater of operations. The expeditions were on the grand scale and distinguished as regards technique by the use of motor transport, to which so much of the Mongolian country lends itself. The advantages of the smooth, flat surfaces are the more apparent in contrast with conditions on "the winding road to Turkestan" where a projected western trip in 1928 had to be abandoned on account of drifting sand. Very impressive are the photographs of the fleet of cars and of the supporting camel caravans, the list of the scientific staff, and the scientific fields represented.

Dr. Andrews gives many graphic pictures of the life of Mongolia, present as well as past. The large area embraced allowed variety of experience: "when crossing Mongolia from the south to the north on the Kalgan-Urga road, we pass through, or meet, four distinct faunal zones: From Kalgan to P'ang Kiang, the South Mongolian Zone of the grasslands; from P'ang Kiang to Tuerin, the Gobi Zone of typical desert life; from Tuerin to Urga, the North Mongolian Zone of grasslands; and from Urga northward the Mongolian-Siberian Zone characterized by many Siberian species and heavy forests of larch, spruce, pine, birch and maple." Variety arises, too, from the marked extremes and sudden changes of weather. Storms and their effects are described; thus of a momentary summer storm: "In its wake lay a

narrow trail of white hailstones, as large as pebbles . . . Throughout the summer this narrow track over which the hailstones were spread remained as a well-defined band of green." Human adjustments to the zones are noted: a comparison is made between degrees of nomadism among the Mongols.

Of political boundaries and political influences in Mongolia Dr. Andrews has something to say. This is the Kalgan-Urga road in 1923: "I never have seen the Kalgan-Urga road as fine as it was that spring. Because of the previous two years of war, cart traffic had ceased and the ruts had all been worn down by weathering and the padded feet of camels. When we crossed the previous year, the plains were deserted. Monasteries lay in ruins; yurts were absent, and no flocks of sheep or goats drifted up the sheltered valleys. If a solitary Mongol sighted the cars, he fled like a frightened animal. With the kaleidoscopic changes which come to these countries of the Orient, the land had assumed the normal aspects of peace in one short year. Yurts clustered near almost every well, like giant beehives; herds fed quietly on the grasslands, and picturesque caravans of majestic camels passed us on the road, carrying loads of skins to Kalgan or merchandise northward to Urga, the city of the Living Buddha."

Admirable photographs, including several panoramas, add to the narrative. For special mention one may single out those of Kalgan from outside the Great Wall, the Sain Noin temple and Lama City, the "Flaming Cliffs" showing the work of wind erosion, and the remarkable picture of the fleet wild asses of Tsagan Nor.

During the winters subsidiary collecting trips were undertaken in various parts of China, and the results are summarized by the participants. The editor of the volume, Chester A. Reeds, gives a comprehensive review of the accomplishments of the expeditions as a whole, and an important chapter discusses the problems—geological, physiographic, biological, and archeological—that have arisen out of the work done.

The extreme southwest of the Central Asiatic Expeditions' sphere approaches the extreme northeast of Sir Aurel Stein's sphere. In three expeditions, 1900–1901, 1906–1908, 1913–1916, in Chinese Turkestan and its borders, Sir Aurel covered 25,000 miles by "quasi-archaic methods"—on horseback and on foot—carrying out archeological and geographical exploration and making a survey with the sole aid of Indian surveyors. The theater of these activities, a great natural highway between East and West, saw the early interpenetration of Far Eastern, Indian, and Western civilizations. Under the desert skies the testimony to these important historical processes has been eloquently preserved. "Never did I realize more deeply how little two thousand years mean where human activity is suspended, and even that of Nature benumbed." At the Niya site on the southern border of Takla-makan "it is particularly easy to reconstruct the conditions of life once led there. The careful construction of the houses once tenanted by local officials or landholders, remains of well-made household furniture and implements, objects of decorative art in the shape of fine wood-carvings . . . Finds of objects of Buddhist worship . . . hundred wooden documents comprising correspondence, mainly official, contracts, accounts, miscellaneous memoranda and the like, all written in that Sanskritic language and Kharoshthi script which during the first centuries before and after Christ were used on the Indian north-west frontier and in the adjacent portions of Afghanistan. We are able to reconstruct almost as clearly the physical aspects . . . Everything in the orchards and arbours dead for sixteen centuries but still clearly recognizable . . . " And a find near Loulan of "pieces of beautifully coloured figured silks, fragments of rich tapestry work and embroidery . . . I could not have wished for a more representative exhibition of that ancient silk trade which had been a chief factor in opening up this earliest route for China's direct intercourse with Central Asia and the distant West."

The rich harvest of Sir Aurel Stein's labors has been described in many splendid

volumes, but the exciting story does not lose in the retelling, gains rather, perhaps, by its necessary concentration on the high lights and the rewards of arduous labor pursued under trying conditions.

The Economy of Present-day China

R. H. Tawney. **Land and Labour in China.** 207 pp.; index. Harcourt, Brace & Company, New York, 1932. $2.50. 8¾ x 5¾ inches.

An outstanding scholar in his own country and accustomed to speak with authority there, Mr. Tawney approaches a consideration of Chinese problems without the oracular quality which so often makes the contribution of foreign experts misleading and worthless. His statement that "it is obviously impossible for visitors to China, unacquainted with her language and unversed in her history, to make any original contribution to the study of her economic organisation and social problems" shows the modest spirit in which he makes his observations. It was his object to take the accumulated knowledge of those who had labored long in the field and to give it some sort of orderly sequence and interpretation. This in itself is a contribution, and he has done the task extremely well. But the book is much more than a mere recitation of facts and figures, for running along with the record is a most stimulating commentary with a good deal of conjecture, but, thanks be, very little prophecy.

Mr. Tawney begins his story with a broad description of the rural framework of China and follows with the specific problems of the peasant and of the possibilities of rural progress. The remaining half of the book is devoted to a discussion of the old industrial order compared with the new and to a chapter on politics and education. This may seem at first glance a rather brief and spotty treatment of so large a subject, but, in fact, the author has managed to bring into this simple framework almost every aspect of the economic life of the country.

Only in a few places has Mr. Tawney seemed to go astray. Exception must be taken to the impression which the book gives in several places that the Chinese farmer is inferior in productive capacity to those in other countries. Statistics are given, based on the approximations of Dr. O. E. Baker, which would seem to show that the yield per acre is lower in China than in other countries. But these statistics are based on only one crop, and apparently no account has been taken of the multiple cropping which is the rule over very large areas of the country. For instance, on the rice land, which produced per acre a yield next in quantity to that in Japan, other crops were also harvested which, if one is seeking to establish the relative efficiency of the respective farmers, ought to be added into the total. It is understandable that an impression of the backwardness of the farmer should have been given, for those—both Chinese and foreign—from whom Mr. Tawney gathered his information were undoubtedly engaged in efforts to bring about improvements in Chinese agriculture. Their emphasis is of course given to improvements which are possible and which should certainly be brought about. But it is probably true that the Chinese farmer is, on the whole, as efficient from the point of view of production of foodstuff as any in the world, and I dare say the West can still learn much from his store of knowledge and experience.

Mr. Tawney thinks that, "apart from a handful of ex-students educated in America, most Chinese would . . . little dream of succumbing to the philosophy of the West." Here again his advisers have made him err, for he has passed along the old theory that Americans have an ability, superior to other aliens, to "de-Chinafy" those who go abroad to be educated. Intimate contact with Chinese who hold degrees from American colleges fails to substantiate this theory—rather the reverse. Those Chinese who have had experience with the ways of life in the New World are more than ever wary and critical, whatever polite remarks they may make about their sojourn there.

Another small point might be brought out which has to do with the strengthening of the central government. Mr. Tawney seems to place rather too much reliance on the beneficent effects which might flow from a more liberal use of foreign advisers through coöperation with the League of Nations. China has engaged foreign assistance, willingly and otherwise, for many decades; and up to now without very satisfactory results. It was only in the case of those services where the foreigners were actually in control that efficiency was established. The fact is that the Chinese want the results which the foreign advice would give them, without actually going through all the intermediate painful processes that are necessary to gain the results. In the end the Chinese themselves must modernize their government. More important still, they must create that spirit of coöperation on the part of the people without which even a good government cannot function. Advisers cannot do that for them. The need, as Mr. Tawney so truly intimates, is not for the forms of organization which Western advisers could supply. It is for a spirit of common sacrifice and solidarity in the enterprise of establishing a more orderly, a more productive, and a more secure form of society.

But these digressions should not be taken as serious criticisms of this most admirable study. It is the best book for a reliable picture of the economy of China today which the reviewer has seen. Meticulous care has been taken to gather and interpret the salient facts, and the story has been illuminated by the impressions gained by the author during his sojourn in China. The whole picture has been projected against Mr. Tawney's profound knowledge of the economic history of Europe, which not only gives it a setting, but throws into bold relief the difference in the Eastern and the Western organization of life.

WALTER H. MALLORY

THE AUVERGNE

PHILIPPE ARBOS. **L'Auvergne.** 224 pp.; maps, diagrs., bibliogr. (Collection Armand Colin (Section de Géographie) No. 147.) Librairie Armand Colin, Paris, 1932. 10 fr. 50. 7 x 4½ inches.

Professor Arbos, whose discussion of "The Geography of Pastoral Life" will be remembered by readers of the *Geographical Review* (Vol. 13, 1923, pp. 559–575), here makes a welcome addition to the growing number of French regional studies. The excellent series in which the volume appears is notable for conciseness of treatment, and "L'Auvergne" is no exception, for the region dealt with in its brief compass is one of great variety. The historic province of Auvergne is the heart of the Central Plateau, but the general term "plateau" is far from applicable. The Auvergne comprises horsts and sedimentary basins, and volcanism and glaciation have contributed to the molding of the land forms. One passes from the broad crystalline plateaus of the west to the Monts d'Auvergne, higher and colder but possessing a fertile volcanic soil; thence one drops to the plains and basins of the Allier with its good soil and clement skies, to rise again to the eastern plateaus and massifs. The production of hydro-electric power and a growing tourist industry in part dependent on the mineral springs are introducing some changes into the country, but the Auvergne yet remains essentially rural. The rural economy reflects the physical diversity—the grainfields of the plain of Limagne, the vines of the bordering hills, the Châtaigneraie, proclaiming southern influences in its exploitation of the chestnut, the forested cantons with their woodworking industries, the combined tillage and cattle raising of the crystalline plateaus and the Dômes contrasting with the almost exclusively pastoral industries of the great volcanic massifs such as Cantal.

The evolution of this varied rural life is described by Professor Arbos both in general terms and in its regional details. Apart from the local developments the Auvergne has always been of interest for its emigration, and several pages are devoted to an analysis of the Auvergnat "diaspora" and of the changes in the

extent and nature of emigration, temporary (seasonal and *à temps*) and permanent. On the latter Professor Arbos quotes the following figures: in 1911 the *départements* of Cantal and Puy de Dôme numbered 223,361 and 525,916 inhabitants respectively, but 77,453 persons born in Cantal and 93,788 in Puy de Dôme no longer lived there. A large proportion of the Auvergnats go to Paris, but of recent years many have been drawn to Clermont, and this is part of a new feature in the urban life of the Auvergne. Thiers, on the eastern border of Limagne, is the old industrial town of the Auvergne and remains a cutlery center, but its population in 1926 was still under 16,000. It is quite otherwise with Clermont-Ferrand, on the western border of the fertile plain. In 1821 the population was just over 30,000 and in 1911 not more than 65,000: by 1926 it had become swollen to 111,711. A combination of circumstances, unanticipated and fortuitous, made Clermont the chief rubber center of France and concomitantly attracted other industries, including the automobile business. A detailed study of the capital of the Auvergne was published by Professor Arbos in 1930, "Étude de Géographie urbaine: Clermont-Ferrand."

An appreciation of "L'Auvergne" by H. Onde appears in the *Revue de Géographie Alpine* (Vol. 21, 1933, pp. 255–260), while a summary account by the author, "L'Auvergne: Les genres de vie dans une province française," with photographic illustrations, appears in the *Bulletin de la Société Belge d'Etudes Géographiques* (Vol. 3, 1933, pp. 57–79).

Contemporary Rumania

Joseph S. Roucek. **Contemporary Roumania and Her Problems: A Study in Modern Nationalism.** xxv and 422 pp.; maps, ills., bibliogr., index. Stanford University Press, Stanford University, Cal., and Humphrey Milford, Oxford University Press, London, 1932. $4.00. 9 x 6½ inches.

Professor J. T. Shotwell has said: "History has many examples of the hard endurance of sects or peoples under persecution . . . But no more remarkable instance of mere vitality and dogged persistence can anywhere be found than that furnished by this [Roumanian] people, so long lost sight of by history itself." The peasant is the backbone of Rumania. More than three-quarters of the people are farmers, but not until as late as November, 1928, did the peasant really come into his own. Actual serfdom was not abolished until the middle of the nineteenth century, to be succeeded only too often by its equivalent in the form of debt bondage and forced labor. The expropriation of the great estates in the Old Kingdom in 1917 and in Transylvania in 1918 and the establishment of a class of small landowners were not followed by any notable improvement in the economic condition of the peasants. Indeed, agriculture as a whole has suffered a decline since the war. Not until the accession to power of the National-Peasant group in 1928 was a program favorable to agriculture put into effect, and on account of the world-wide depression its effects are hardly apparent as yet in any material form.

Of all the many problems that contemporary Rumania is facing, Professor Roucek considers the raising of the economic level of the country to be of first importance. A Rumanian statesman has said: "Roumania is a poor land, though rich with natural wealth." There are enormously productive wheat and maize fields on the black soils of the Danubian plain. Timber from the Carpathian forests is floated down the rivers and exported to Budapest and Vienna and to the other Balkan states. Cereals, animal products, and timber constitute nearly three-quarters of the exports. In Europe, moreover, Rumania is second only to Russia in petroleum production. In its undeveloped natural wealth it seems more like a recently settled colonial nation than like the countries of western and central Europe.

These and many other economic and political problems of contemporary Rumania are ably discussed by Professor Roucek. The history of the country is outlined down to 1914 and traced in considerable detail from 1914 to 1931. The chapter dealing

with Rumanian foreign relations and the Little Entente may be read with profit by all who would understand the conflicting forces at work in southeastern Europe today. The question of minorities is fairly analyzed, stress being laid on the dangers of irredentism and the need of tolerance no less on the part of the minority peoples themselves than on that of the state. "One becomes more and more impressed with the feeling that the spectacular has crowded out all sober understanding of Roumania as a nation and as a people, if indeed such ever existed." Roucek's book, in which Rumania's case is soberly upheld, should help reëstablish such an understanding.

The Baltic Countries

E. G. Woods. **The Baltic Region: A Study in Physical and Human Geography.** xvi and 434 pp.; maps, diagrs., ills., bibliogr., index. E. P. Dutton and Co., New York, 1932. $5.50. 9 x 6 inches.

Although geographers and geologists of the Baltic countries have built up a voluminous and scholarly literature on the region as a whole and have also contributed numerous superb intensive treatises on local areas, the majority of these writings are in languages other than English, and many are not readily available. Mrs. Woods has rendered valuable service in presenting a compilation of the material in a systematic and readable manner. Unfortunately space limitations prevented a balanced treatment of the two geographical aspects described in the subtitle of the book, namely, "Physical and Human Geography." The latter phase of the work is highly condensed, even incidental except in a few instances. As the author herself states, the work is "mainly a scientific explanation of the physical features."

Mrs. Woods reveals not only a thorough acquaintance with the literature of the Baltic region but also a first-hand knowledge of the territory she discusses, gained through direct observation, and she quickly gains the reader's confidence. Apparently she is not attracted by the terminology current among American geologists and physiographers, for she not only utilizes translations of German and other foreign expressions but (p. 113) makes direct reference to the "uneuphonious titles of 'knob and basin topography' or 'kettle range' " given by American geographers to certain formations. To her credit, she is not held in bondage by tradition as exemplified by the full recognition and usage of new geographical names adopted by the respective countries during the post-war period. Again, the reviewer is glad to read the challenge (p. 197) to the oft-quoted description of Stockholm as "the Venice of the North"—". . . no child-god, given the same elements of earth, sea and sky to play with, could have fashioned two cities more unlike."

Adverse criticism of a scientific treatise, particularly one possessed of originality, is not difficult to advance. Here attention is directed to a few items that might be improved in a second edition, although they do not seriously detract from the present volume. The geological sketch map on page 42 seems to be too highly generalized. In a region wherein the sedimentary series are so scarce, their entire elimination as occurs in Sweden in the vicinity of the 60th parallel is regrettable. The division of Finland (p. 202) into three physical natural regions might well be further refined into five by dividing the "upland region" into three parts, one dividing line to be placed in the vicinity of the Oulu River valley and the other at the southern end of the Petsamo district, and finally separating the highland area of the Scandinavian mountains in the extreme northwest of Finland from the "northern Upland Lake District" (see map, p. 7, in "Finland: The Republic Farthest North"). On page 306 the terms "climatic" and "geographical" are listed in a parallel sense. One may well question their parallelism. Here and there the spelling of geographical names is in error due apparently to the typesetter's oversight.

The illustrations consist of interesting pen and ink sketches, some made from photographs and others direct. The author is to be commended for having broken

away almost completely from the all-too-frequent defect among British writers of omitting from their maps meridians and parallels or equivalent indicators. A well selected bibliography adds greatly to the value of the publication.

EUGENE VAN CLEEF

THE "AMERICAN SOUTH"

RUPERT B. VANCE. **Human Geography of the South: A Study in Regional Resources and Human Adequacy.** xiv and 596 pp.; maps, bibliogr., index. (Univ. of N. C. Social Study Series.) University of North Carolina Press, Chapel Hill, 1932. 8½ x 5½ inches.

A wonderful collection of material on the South: interesting material, too, almost every word, and some of it geographic. Many of the descriptions, usually quotations, are admirable, a well-selected collection of passages. From them may be built up a completer picture of the South than any that I know of, but superficial and at times confused.

Dr. Vance says he "aims at a synthetic treatment of the interaction of men and nature in the American South." But should not *synthetic* presuppose the union of things that change in the uniting? The author seems to account it synthesis when different things are brought together. The book lacks synthesis. Facts are brought together, at times only pseudo-facts, as critical examination is lacking. There is not much study and testing of actual effects of things upon one another. Many students hesitate to follow Dr. Huntington's climatic ventures, but it is unfair to cite against him without report of the objecting arguments an unpublished M. A. thesis by a student in the University of North Carolina (p. 362). For the most part opinions are set out, and the reader is left to form his own impressions.

The South is not delineated with definiteness except on the end papers, which make it the South of the census less West Virginia, Maryland, and Delaware, thirteen states, that is. Ten would be better, we are told, but not which ten.

Chapter I is headed "The Concept of the Region," but that turns out to mean of regions in general. Dr. Vance quotes from Sauer that "regional studies must describe, interpret and analyze regions." He cites attempts of those who have tried, referring to Spencer, Turner, Barrows, Colby, Dawson, Whitbeck, Marsh, Joerg, Davis, Fenneman, Köppen, Merriam, Greeley, Dice, Vidal de la Blache, Le Play, Brunhes, Vallaux, Spillman, Baker, Keyserling, Bruere, Geddes, Branford, and Darrell Davis. What emerges is substantially Powell's physiographic regions of the 1896 monograph as modified by Davis in 1898, with the slightly different names applied by Fenneman. Vance draws no conclusion except that the South is difficult to define.

Dr. Vance does not appear to have had geographic or geologic training, if we may judge from such phrases as a "pocket of rock, variously called an anticline, a dome, or fault" (p. 336). In Chapter II, "The South's Profile," Geddes' Valley Section is propounded. But where Vance speaks of "the mountain's steep escarpment followed by the dip slope of the highland," he does not appear to recognize that dip and dip slope have definite meanings in geology that could not possibly apply to the region above the Piedmont. He takes profiles in various directions: "Three valley sections . . . come together at the apex of the southern Appalachians, forming what we may call a trihedral angle." How can they when a trihedral angle is the corner made when three and only three planes come together? The profiles do not seem to the reviewer helpful to the understanding of the South or its physiography. The author does not include Bailey Willis on the northern, nor Willard Hayes on the southern Appalachians in his list of more than 1000 titles, nor Davis's five admirable pages on the South in Mill's "International Geography," nor Cleland's

illuminating "Black Belt of Alabama" in the *Geographical Review* (Vol. 10, 1920, pp. 375–387).

There is no mention of the early and long-lasting advantage to the South from a commercial agriculture that produced wealthy land owners at a time when lack of communications kept the rest of the country to sustenance agriculture and homespun. There is no study of the ships and shipping of tidewater Virginia, which made that commerce possible. It is even suggested (p. 234) that the western side of Chesapeake Bay, with its ten railless counties, is the "Eastern Shore"! But there is no space here for further geographical criticism.

Of social things there are many excellent pictures—the oil boom in the Southwest, the new cotton and rice culture in Texas, and the diseases of the South. It is a book of excellent deserts had it not attempted to be a geography.

MARK JEFFERSON

THE WISCONSIN DOMESDAY BOOK

JOSEPH SCHAFER. **The Wisconsin Lead Region.** ix and 341 pp.; maps, ills., index. (Wisconsin Domesday Book, General Studies, Volume 3.) State Hist. Soc. of Wisconsin, Madison, 1932. 8¼ x 6¼ inches.

This volume, Number 3 in the general series of the Wisconsin Domesday Book, is the second of the Regional Studies. The first, "Four Wisconsin Counties, Prairie and Forest," 1927 (see *Geogr. Rev.*, Vol. 18, 1928, pp. 519–520), treated of the southeastern part of Wisconsin, and this study of the lead region covers the three counties in the southwestern part of the state. In both these works the historical philosophy of Frederick Jackson Turner finds expression. In his study of Wisconsin Dr. Schafer has recognized the importance of the region as Turner recognized the sectionalizing influence of the physical *milieu* as the frontier and its accompaniments spread across the country.

The author introduces the reader to the lead region by a general chapter on "The Story of Lead (1790–1861)" and follows this with a non-technical description of the Galena-Trenton cuesta landscapes south of the lower Wisconsin River. Eight chapters are largely devoted to lead mining, which began about 1820 and continued down to 1860. He traces the development of the mining industry, noting the rapid rise of lead production after 1822. He carefully examined the early manuscript census reports to discover the make-up of the population and found among other things that no other section of Wisconsin had so high a proportion of settlers from the southern and southwestern states. The foreign-born were mainly British in origin with Cornish miners very numerous, but later the British element was diluted somewhat by other nationalities. The rapid settlement of the mineralized area in the southwestern part of Wisconsin made that district very important in governmental affairs. In 1838 the lead district had a representation in the territorial legislature equal to 28 per cent, but by 1860 this had been reduced to 10 per cent.

To the subject of the agricultural utilization of the land Schafer presents three chapters and gives detailed quantitative data to indicate the importance of the raising of beef cattle and swine in the early period, which was later followed by a specialization in dairying.

The last three chapters are devoted to a study of the population; as a full century has elapsed since the beginning of settlement the author has an opportunity to analyze the character and distribution of the inhabitants.

In Appendix II, Paul A. Schafer reviews the origin of the lead and zinc deposits of the region, and in Appendix IV, Professor Vernor C. Finch presents a brief summary of his study of "The Service Area of Montfort." The village of Montfort is situated on the crest of the Galena-Trenton escarpment, and the service area extends down toward the Wisconsin River and includes a part of the dissected margin of

the cuesta plateau. This field investigation and the author's careful analysis of the early census data, so far as they apply to the lead region, make this a study in regional-economic history.

The reader who is familiar with the literature of the area will miss reference to Dr. Selma Langenhan Schubring's "A Statistical Study of Lead and Zinc Mining in Wisconsin" (*Trans. Wisconsin Acad. of Sci., Arts, and Letters*, Vol. 22, 1926, pp. 9–98) and Professor W. O. Blanchard's "The Geography of Southwestern Wisconsin" (*Wisconsin Geol. and Nat. Hist. Survey Bull. No. 65*, Madison, 1924). Certainly these two works, although they are secondary sources, deserve mention.

GUY-HAROLD SMITH

THE MISSISSIPPI RIVER TRAFFIC QUESTION

JOHN D. SUMNER. **An Analysis of Mississippi River Traffic: 1918–1930.** Diagrs. *Journ. of Land and Public Utility Economics*, Vol. 7, 1931, pp. 355–366; Vol. 8, 1932, pp. 11–23.

The constantly increasing traffic of the Mississippi River since the low ebb of 1916–1918 and the commodity characteristics of this traffic are analyzed in this article. The new régime of the river traffic inaugurated by the federal government working through the Inland Waterways Corporation carries none of the questionable or inherited characteristics of the old, since the adequate financial backing of the government has allowed the building of improved terminals and a modern fleet of carriers. Furthermore, the former controversies between the rail and water transports have been stilled by force, and today a considerable degree of railroad coöperation exists through interchange and joint rates. Traffic has been concentrated at comparatively few large centers, shipments are gradually becoming long-haul or through-freight, and the disparity between the north-bound and south-bound tonnage which has caused in recent years such unbalanced loads is being overcome by the development of a substantial north-bound tonnage. All these Mr. Sumner demonstrates by tables and graphs; and he controverts the assumption that inland waterways are restricted to the transportation of low-value bulky commodities, leaving more lucrative high-value traffic to the railroads. The analysis of the Mississippi River traffic and selected railroad freight indicates that the former is of a grade substantially similar to that of the latter. The federal barge line has deliberately developed a diversified traffic by reducing the chances of damage during transportation and in the terminals and by the federal forcement of interchange imposed upon the railroads.

The analysis is thorough and well substantiated by tabulated data. It would have been interesting to know at what cost all this is done. With the government paying the overhead, low rates can be assured the shipper, of course, and this in itself will attract freight. The Mississippi River traffic question is not so much one of decreasing or increasing load, but whether or not shipping on the river can be made to pay on the substantial investment, without too much Congressional legislation, federal forcement, and federal parentage.

ROBERT M. BROWN

CHRONICLE OF TRANSPORTATION IN THE OHIO COUNTRY

CHARLES HENRY AMBLER. **A History of Transportation in the Ohio Valley.** 465 pp.; maps, ills., index. Arthur H. Clark Co., Glendale, California, 1932. $7.50. 9¼ x 6¼ inches.

The Ohio country, that indefinite area adjacent to and drained by the Ohio River, has sufficient regional character to deserve special study. Professor Ambler presents in this history a rather comprehensive regional analysis, though his emphasis

is on the development of the facilities of commerce. He follows a preliminary discussion of the river with a chapter on "The Boatmen and Their Craft." Here he distinguishes between the various carriers, such as the barges, flatboats, keel boats, and packetboats, that were so important in the development of interior America. The shipbuilding industry receives attention in one chapter, and this is followed by a discussion of the steamboat traffic.

The canal building period is considered with the road building program, for these two highways of commerce did much to relieve the Ohio Valley of the curse of isolation. The author again returns to the river to give the passenger packet its proper place in the development of commerce. After 1850 the railroads began to be serious competitors of the packetboats, and the conflict between the carriers of commerce led to intermunicipal rivalries. The author has reviewed in some detail the conflicts between Pittsburgh and Wheeling and between Cincinnati and Louisville, pointing out how their strategic positions gave them economic and commercial opportunities.

The Civil War brought uncertainty to the rivermen and the shipping industry, but as soon as hostilities ceased the river resumed its place in the development of the Middle West. Trade with the south was revived as the barges bore coal, petroleum, and other products southward and returned with molasses, sugar, cotton, and subtropical products. But in the eighties the increased competition of the railways, the irregularities in the flow of the river, and the competition between the various lines brought river transportation into financial difficulties. The coal trade, which began about 1812, saved barge transportation from the fate that befell the packetboats. The coal boat, a specially designed craft, has evolved from a small boat holding only a few tons of coal to the modern steel barges that are moved in great fleets by a single towboat.

The chapter on "Commercial Decadence," which covers the period from about 1890 down to 1917, is treated in great detail and lacks the synthesis desirable in such a study. The author's allegiance to the recital of historical details makes his book chiefly a chronicle and not an interpretative work, for he touches too lightly on such subjects as real costs of freight on the Ohio River as compared with the apparent low rates. A critical appraisal of the river craft as compared with the railways as common carriers would have made this book an indispensable economic history.

GUY-HAROLD SMITH

THE GREAT BARRIER REEF

T. A. STEPHENSON, ANNE STEPHENSON, GEOFFREY TANDY, AND MICHAEL SPENDER. **The Structure and Ecology of Low Isles and Other Reefs.** Maps, diagrs., ills., bibliogr., systematic index. (Great Barrier Reef Expedition, 1928–29, Sci. Repts., Vol. 3, No. 2, pp. 17–112.) British Museum (Natural History), London, 1931. 20s. 12 x 9 inches.

SHEINA M. MARSHALL AND A. P. ORR. **Sedimentation on Low Isles and Its Relation to Coral Growth.** Diagrs., ills., bibliogr., index. (Great Barrier Reef Expedition 1928–29, Sci. Repts., Vol. 1, No. 5, pp. 93–133.) British Museum (Natural History), London, 1931. 5s. 12 x 9 inches.

"The Structure and Ecology of Low Isles and Other Reefs" extends the picture of typical features of the Great Barrier Reef already presented by J. A. Steers (The Queensland Coast and the Great Barrier Reefs, Part I, *Geogr. Journ.*, Vol. 74, pp. 232–257) and M. A. Spender (Island Reefs of the Queensland Coast, *Geogr. Journ.*, Vol. 76, pp. 193–214 and 273–297). The attractive maps of Low Isles and Three Isles, on a scale of 1 : 5000, that accompanied Mr. Spender's paper are here reproduced. The word "structure" in the title, it may be noted, refers to surficial features only.

Low Isles, a reef lying in the lagoon 25 miles behind the zone of outer reefs and 8 miles from the mainland, serves as the standard type for comparing the different

kinds of reefs. It is a heart-shaped body one mile long and three-fourths of a mile wide, the apex of which points southeast toward the direction of the prevailing winds. The reef rises at an angle of about 15° from the more or less even floor of the lagoon 75 feet deep, to about mean sea level. The top of the reef is nearly flat and, except for a small sand cay rising about 7 feet above maximum high tide level at the leeward end of the reef, has a relief of about 10 feet, which is the range of the extreme tides. The windward sides of the islands are bordered by two concentric ramparts of gravel. The crest of the outer rampart varies in elevation from about mean sea level to 3 feet above mean sea level. It is separated from the inner rampart by a moat "nowhere more than 18 inches deep at low water." The moat has a maximum width of 100 yards, but in places it has been obliterated by the transgression of the outer rampart upon the inner rampart, which rises nearly to mean sea level. The southern half of the northwest or leeward end of the key is bordered by a rampart composed of boulders of coral rock several feet in diameter, tentatively ascribed to hurricanes. Just inside the boulder tract lies the cay of coral sand having an area of 3.5 acres. For nearly one-fourth of a mile northeast of the cay the reef is not bordered by gravel or boulder ramparts but is embayed for a distance of 500 feet. The interior part of the reef is nearly flat and consists of clastic deposits of coral origin, ranging in texture from fine clay to fine gravel. Mangroves grow densely on the windward side of the reef behind the barrier ramparts.

The writers enumerate the various organisms that grow in different parts of the reef. They discuss first each environment and its inhabitants, and then they describe the distribution of individual groups of plants and animals among the various environments.

Four other reefs were studied—Three Isles, a lagoonal reef almost identical with Low Isles; Batt and Yonge Reefs on the seaward border of the barrier reef zone; and the reefs fringing Lizard Island, a mass of granite rising 1100 feet above the floor of the lagoon, 15 miles inside of the outer reefs. The outer reefs, Batt and Yonge Reefs, rise only to the level of low spring tides; consequently they do not possess the features characteristic of higher zones on Low Isles. However, the areal features of any particular level resemble those of corresponding levels on Low Isles, except that the interior sand flats characteristic of the lagoonal reefs are not present. The reviewer receives the impression from the data given that the strength of the waves influences strongly the development of the reefs along the Great Barrier Reef.

The article is written from the viewpoint of the biologist, and one may wish that the authors had included more observations on the morphological features of the reefs, such as additional data concerning the size of the gravel on the shingle ramparts, the size of the clastic débris on the sand flats, the angle at which the ramparts border the reef slope, the depth of the moat between the ramparts, the relation of the boulder tract to mean sea level, and at what particular tide level the sand cay has an area of 3.5 acres.

The writers discuss the coral reef problem only briefly. Their task was to describe the features they found on the Great Barrier Reef. As the result of the twelve months' intensive field study of the Barrier Reef by them and their coworkers, they feel that coral reefs are complex in origin and that many more data are needed to solve the problem.

The paper on sedimentation presents (1) measurements of the quantity and size of the detrital constituents in suspension in the water at various depths in several places at different times of the year on Low Isles Reef, (2) results of boreholes on Low Isles Reef, and (3) data relating to the influence of detrital particles on the growth of corals. The results of the first series of experiments showed that there was a direct correlation of the amount and coarseness of the débris in suspension with the strength of the winds and with the coarseness of the sediments on the reef beneath.

The boreholes showed that from the surface of the reef to about 5 feet below the

level of low water the reef consisted of a mixture of coral sand and rock fragments and that from 5 to at least 15 feet below low water it consisted of soft dark gray calcareous ooze. The layer of marl was found in every borehole except one, where hard rock was encountered at the depth at which the marl layer was expected. Two boreholes a few feet away, however, encountered the marl layer at the expected depth. These phenomena suggest to the reviewer that the rock encountered might be a buried mass of coral similar to the mushroom growths of coral now forming at a similar level in water on the leeward side of the reef. The sandy zone at the surface of the reef is discolored black, but it contains a relatively small amount of organic matter compared with the underlying marl layer, which is dark gray. The organic content of the sand zone is less than 0.5 per cent, while that of the marl zone is about 3 per cent. The organic content of the sediment in the overlying water ranges chiefly between 3 and 5 per cent of the particles in suspension.

In the experiments relating to the influence of sediments on the growth of corals coral sand, silt, and clay were dropped on living and dead corals in the actual place in which they grow and on living corals in an aquarium. The object of the experiments was to ascertain the relative influence of currents and of ciliary and body movements of the corals in removing débris. It was found that all the corals tested were able to remove some sediment, but the action was more favorable under natural than under artificial conditions. Currents aid the removal of débris because dead corals were cleared of sediment sooner in windy than in calm weather.

PARKER D. TRASK

THE "DISCOVERY" REPORTS

J. M. CHAPLIN. **Narrative of Hydrographic Survey Operations in South Georgia and the South Shetland Islands, 1926–1930.** Maps, ills. (Discovery Reports, Vol. 3, pp. 297–344.) Cambridge University Press, 1932. 10s. 12½ x 9½ inches.

H. F. P. HERDMAN. **Report on Soundings taken during the Discovery Investigations, 1926–1932.** Maps (in separate case), ills. (Discovery Reports, Vol. 6, pp. 205–236.) Cambridge University Press, 1932. 15s. 12½ x 9½ inches.

The hydrographic surveys and soundings of the recent *Discovery II* expeditions in the southwestern parts of the Atlantic Ocean and the adjacent parts of the Southern Ocean have provided data of fundamental importance for interpretation of the geographical and tectonic relations of the region.

The first of the memoirs narrates the survey work of R.S.S. *Discovery* and her auxiliaries during 1926–1930. The work, which was attended with much danger and difficulty, is recorded in four fine charts, three of them covering South Georgia and its harbors and anchorages, the fourth giving plans in the South Shetlands, South Orkneys, and the vicinity of Graham Land. Valuable appendixes deal with personnel and equipment, records of magnetic variation, weather and climate in South Georgia, and kelp. Five magnificent plates provide scenic pictures full of instruction for geologist and geographer. Several of these show a well marked plane of marine abrasion about 80 feet above sea level around the coasts of South Georgia.

The soundings recorded in the second memoir were made partly by wire and partly by echo, and an instructive comparison of the two methods shows that down to 5000 meters the echo method is by far the more accurate and gives somewhat smaller readings than the wire. This is due to the fact that the wire always deviates from the vertical however carefully the ship is maneuvered. The soundings were chiefly made in the region between Tierra del Fuego and the South Sandwich Islands, but additional readings were obtained in the neighborhood of the South Shetland Islands and in the Bellingshausen Sea.

The new soundings, taken in conjunction with those of the *Meteor* expedition, throw a flood of light on the question of the "Southern Antilles," or, to use Wordie's more correct designation, the Scotia Arc. This is the hypothesis, first put forward by Eduard Suess, that the tectonic lines of the Andes, which bend eastward in Tierra del Fuego, join up with the homologous lines in Graham Land by means of a great loop of submarine ridges and islands, passing through Staten Island, the Burdwood Bank, the Shag Rocks, South Georgia, the Clerke Rocks, the South Sandwich Islands, the South Orkney Islands, Elephant and Clarence Islands, and the South Shetland Islands, which encloses the Scotia Sea. Mr. Herdman has written an excellent general discussion of this question and has dealt with the evidence in detail. He points out the great geographical importance of the question, for if the missing parts of the arc are represented by submarine ridges they will certainly exert a profound influence on the movements of the water masses in their vicinity, especially as they are situated across the southern junction of the Atlantic and Pacific Oceans.

Suess's suggestion met with strong opposition from the late J. W. Gregory and from R. Staub, who saw in South Georgia a fragment of an ancient South Atlantic land, and who, like Kühn, saw no evidence of a connection in the contours of the intervening sea floor. Later geological work by Heim, Wordie, and Holtedahl, and paleontological determinations by Wilckens, have shown that in both structure and rock composition South Georgia closely resembles the southern extremity of South America. The evidence of the *Discovery* and *Meteor* soundings is strongly in support of Suess's original view, for they show very definitely that there are concentric submarine ridges that join up the various islands situated on the Scotia Arc.

The memoir is illustrated by three excellent plates showing respectively soundings and oceanic contours over the whole region of the Scotia Sea, in more detail around South Georgia and the Shag Rocks, and in the neighborhood of the South Shetland Islands.

G. W. TYRRELL

GEOGRAPHICAL KNOWLEDGE IN ANTIQUITY

HARRY E. BURTON. **The Discovery of the Ancient World.** 130 pp.; maps, bibliogr., index. Harvard University Press, Cambridge, 1932. $1.50. 8 x 5½ inches.

This excellent little book is written for the layman as well as for the professional geographer and classicist. The latter is rightly scored by the author for his notorious ignorance of ancient geography, though anthropogeography has been interwoven with history since Herodotus' day.

Dr. Burton traces the extension of geographical knowledge in antiquity, beginning with the Egyptians, Cretans, and Phoenicians and carrying the story through the Greeks and later Romans to the time of Ptolemy in the second century of the Christian era, when geographical discovery for the ancients ended. As the Greeks and Romans were only rarely scientific geographers and seldom sent out exploring expeditions for the purpose of widening their knowledge, the "discovery" of the ancient world was mostly effected either through trade, colonization, and conquest or as a by-product of military expeditions, such as those of Alexander in the East and of Caesar in Gaul. The few ancient exploring expeditions are, however, mentioned, from the Phoenician circumnavigation of Africa in the reign of the Egyptian Necho (610–594 B. C.) down to the two journeys across the Sahara into central Africa undertaken by Septimius Flaccus, governor of Africa, and Julius Maternus in the first century of the Christian era.

The conciseness of treatment excludes all controversial matter, both the many tales of strange lands and peoples found in the ancient writers, who only partially understood them, and modern theories about them. The omission is compensated in part by a bibliography of modern works (pp. 113–119) listed in the order of their

publication, beginning with Movers' now antiquated "Phoenizier" (1841–1856) and ending with Ellen Semple's "Geography of the Mediterranean Region" (1931).

The author shows (pp. 8–9) how recent knowledge of Cretan activity in the Mediterranean from the Aegean to Spain has robbed the Phoenicians, long regarded as the sole precursors of the Greeks, of much of their importance in early discovery. He is doubtless right in saying (pp. 9–10) that the Phoenicians had nothing to do with the sea or overland trade in tin and amber but merely distributed these wares over the Mediterranean after local carriers had brought them to Gades, Tartessus, the head of the Adriatic, or elsewhere. His epitome of Strabo's books (pp. 68–76) is a model of clear condensation. In speaking of Mela (pp. 76–81) he remarks that geography as an independent field is almost nonexistent in Latin literature, the Roman historians introducing geographical material only incidentally; but he does not bring out the astonishing fact that the Romans, the conquerors of the known world, showed practically no interest in the various lands and peoples of their empire. While showing (p. 80) how vague rumors of the Volga must have given rise to the notion held by most of the ancient geographers—Hecataeus, Eratosthenes, Strabo, Mela—that the Caspian was connected with the Northern Ocean by a long, narrow strait, he does not emphasize the glory of Herodotus in being the only writer before Ptolemy who declared it an inland sea.

As the book is so largely concerned with statements of fact, it contains little with which one might differ. Caesar's Rhine bridge was not "probably" but certainly "between modern Coblenz and Andernach" (p. 62). The idea that the existing "Itineraries" date from the fourth century (p. 68, cf. p. 108) is contradicted by the author's statement that the two Antonine Itineraries (we generally speak of one) originated in the time of Caracalla and were revised in the reign of Diocletian. That Augustus "had no ambition to increase the territory of the Empire" nor "to expand the frontiers beyond the Rhine" (p. 81) is vitiated by his Alpine wars, carried on by his step-sons Drusus and Tiberius, by his erecting the provinces of Rhaetia, Noricum, and Pannonia, and by Varus' unsuccessful march into Germany in 9 A. D. That Hipparchus should be introduced merely "as an astronomer of Nicaea in Bithynia" (p. 57) does scant justice to one of the world's greatest geniuses—the founder of scientific astronomy, discoverer of the precession of the equinoxes, inventor of the astrolabe (recently revived by Professor Jenkin of Oxford, and the oldest scientific instrument in the world), inventor of trigonometry and a table of chords similar to our sines, accurate measurer of the solar year and the lunar revolutions, whose observations formed the basis of Ptolemy's "Almagest," which wielded absolute sway over Europe, North Africa, and western Asia for centuries!

WALTER WOODBURN HYDE

THE WORK OF AN ITALIAN GEOGRAPHER

LUIGI DE MARCHI. **Memorie scientifiche 1883–1932.** Raccolte da colleghi, allievi ed ammiratori in occasione del suo 75° compleanno. lxxi and 854 pp.; maps, diagrs., ills. Casa Editrice Dott. A Milani già "Litotipo," Padua, 1932. 11 x 7½ inches.

In honor of Professor Luigi De Marchi on his retirement from the chair of physical geography at the University of Padua "colleagues, students, and admirers" produced this large volume containing no less than forty-three reprints of his scattered papers and monographs. Most of these publications originally appeared in Italian serials difficult to obtain in American libraries.

To the "Memorie scientifiche" Professor Giotto Dainelli contributes a tribute in the form of a biographical note and broad estimate of De Marchi's work (see also Roberto Almagià: Il giubileo di Luigi De Marchi, *Riv. Geogr. Italiana*, Vol. 39, 1932, pp. 129–132). Before he was appointed professor at Padua in 1903 De Marchi for

twenty years served as librarian in several of the larger libraries of Italy. While his duties in this capacity made it impossible for him to pursue investigations in the field, they did not prevent him from doing constructive and original work in climatology and meteorology. His approach to these subjects was, perforce, largely from the mathematical and physical points of view, and he perfected a skill in the application of mathematical and physical principles to the solution of geographical problems that gave a distinctive quality to much of his later work in physiography and geophysics. Outstanding among his studies during this early period was the development of a theory of the causes of the Pleistocene glaciation. He also published the manuals entitled "Meteorologia generale" (1888, 2nd edit. 1905) "Climatologia" (1890, 2nd edit. 1932), and "Trattato di geografia fisica" (1902). The last-named served to make known to Italian geographers "doctrines that at the time were scarcely recognized among [them], as for example the morphological ideas of the American school of Davis."

After becoming professor De Marchi was at last in a position to undertake fieldwork, and his interest turned from theoretical studies to the physical features of his native country and its adjacent seas. He carried out investigations of the subterranean waters in the alluvial deposits of the Po Valley as well as in the calcareous rocks of the Asiago Plateau and in karstic regions elsewhere. He examined the shore lines, lagoons, and currents of the Adriatic and Mediterranean. A comprehensive survey of the oceanography of the Adriatic was conducted under his direction. He based an explanation of the contour of the bottom of that sea partly on the theory that sea level was generally much lowered during the Pleistocene period by storage of water in the ice sheets. He made a brilliant interpretation of the geomorphology of the Euganean Hills from an analysis of the drainage pattern. He became an advocate of the hypothesis of isostasy.

De Marchi has written several textbooks and many minor papers in the field of physical geography and in economic and political geography as well. One hundred and fifty-seven titles are listed in the bibliography of his publications.

World Economy in Pictorial Maps

Gesellschaft und Wirtschaft: Bildstatistisches Elementarwerk. 130 pls. incl. maps, diagrs., tables, bibliogr., index. Prepared by Das Gesellschafts- und Wirtschaftsmuseum in Wien. Bibliographisches Institut, Leipzig, 1930. RM. 58.50. 18 x 12 inches.

This loose-leaf atlas is the first monumental product of the "Vienna Method." The Vienna Gesellschafts- und Wirtschaftsmuseum, having to appeal to the masses rather than to specialists, has evolved a simplified technique. It attempts to phrase various problems of sociology and world economics pictorially, upon the background of a colored map. Symbols are used to express the populations, resources, products, potential wealth, comparative armaments, and industries. The object is to create a compendium of geographical and historical knowledge sufficient for any broad understanding of world affairs.

Whatever the problem, a way of illustrating it has been found. One may mention, for instance, the treatment of migration questions in the Pacific, where are shown the lines of migration forced on the one hand by overcrowding in China and Japan and encouraged on the other by the vacant spaces in Mongolia, Manchuria, Malaysia, Oceania, Australia, and the Americas; or the persistence of the traffic in slaves; or the spread of Arabian influence under the impetus of Islam. Seventeen of the plates are devoted to the ancient world, Rome, Arabia, Mongolia, India, Central and South America, Mesopotamia, etc., showing the shifting trade routes, religious centers, pasturage areas, cities, and racial groups. These are interesting and excel in artistry of presentation, but the work is at its best in political and economic

exposition. The British, French, Russian, and American empires are treated each in a series of maps showing growth in area and population. The monopolies held by Chile, Great Britain, Germany, Japan, Sweden, Brazil, Russia, and the United States are illustrated and the origins and movements of the chief world staples. Occasionally the map is not used, symbols standing alone. Quantity is indicated not by the contrast between symbols of varying size but, instead, by the use of the same-sized symbol for a certain definite amount repeated as often as required. The intelligibility of the general charts is thus assured, while a concise text and statistical appendix give precision. In addition there are key charts to symbols and map projections. "Gesellschaft und Wirtschaft" is fascinating in its scope, its beauty, and its possibilities.

WILLIAM LEON SMYSER

CHILE IN PICTURES

ROBERT GERSTMANN. **Chile.** 66 pp. of text, 280 pp., ills.; map, index. Braun & Cie, Paris, 1932. 192 fr. 12¼ x 9½ inches.

Aucanquilcha, Aconcagua, Lonquimai; Llaima, Villarica, Lanin; Mocho, Choheuco, Puyehue; Calbuco, Osorno, Puntiagudo, and Tronador, proud peaks of the Chilean Cordillera, lovely as their names; and the equally lovely lakes, Lanalhue, Esmeralda, Riñihue, Todos los Santos . . . Here too are the desert oases, Pica, Matilla; nitrate *oficinas* and ports, Iquique and Antofagasta; mining plants, Chuquicamata and Potrerillos, and old mining towns, Copiapó and Vallenar; Santiago and pastoral scenes of the Central Valley; the snowbound Transandine Railway; the Araucanian country and its brave native folk; the sheep farms of the south and the intricate channels of Tierra del Fuego. Surely Chile of all countries lends itself to photographic portrayal for geographical purposes. Its longitudinal stretch of 2500 miles and its altitudinal reach of nearly 23,000 feet hold an infinite variety. Herr Gerstmann is not a geographer, but he has an eye for country, and his pictures are not only artistic but representative and instructive. Compare the transparent quality of the light in the high-altitude oasis of San Pedro de Atacama (No. 11) with the "winter day of incessant rain at Puerto Aysen" (No. 225) or the palms of Ocoa (No. 101) with the tidewater glacier of the Beagle Channel (No. 273). "Chile" contains 280 reproductions in photogravure, many of them aerial views, from the author's large collection. They are arranged in regional order, and there is a brief accompanying text in Spanish, German, French, and English. As a whole this volume is even better than its predecessor "Bolivia," published in 1928.

A RUSSIAN TREATISE ON TIDES

N. N. ZUBOV. **Elementarnoe Ychenie o Prilivakh v More** (Elementary Treatise on Tides). 125 pp., maps, diagrs. Gidro-Meteorologichesky Komitet SSSR i RSFSR, Moscow, 1933.

This little book has grown out of a series of lectures delivered in the Hydro-Meteorological Institute in Moscow. Its aim is to provide an easy access to tidal problems, which in the opinion of the author are bound to receive more and more consideration in the field of dynamical oceanography, especially in its chemical and biological phases. It leads the student in a systematic way to an understanding of the various phases of tidal knowledge.

After presenting the fundamentals of the static theory of tides, based almost exclusively on George H. Darwin, the author discusses its shortcomings, using this as an approach to his second main chapter, the dynamical theory of tides. The works of Spindler, Schokalsky, Rozhdestvensky, also special papers of Helland-Hansen, Pettersson, Shuleikin, and Liakhnitsky, form the basis for this part of the treatise. Valuable practical tables are inserted. The author's presentation of

the theory of seiches deserves particular mention. A typical local flavor is reflected by a section dealing with the influence of ice cover upon the elements of the tide.

A large part of the book is devoted to the principles of harmonic analysis and tidal prediction. A special feature is a table showing the changes of tidal constants within the short span of four years (Bombay tides). A short section discusses the cotidal world maps of Harris and of Sterneck. Zubov is inclined to agree with Krümmel on the doubtful merits of these attempts, as too hypothetical and too arbitrary. A world map of amplitudes along the continental shores is badly handicapped by inadequate print and size.

A brief chapter discusses tides in their influence upon the hydrological régime of the oceans and also the economic significance of the tides as a source for hydroelectric power. Tidal localities within the sphere of the U. S. S. R. are chosen for numerical examples.

In conclusion the author brings to the attention of the student—chiefly in the form of open questions—the actual and possible interplay of tidal motions in their intimate association with the entire field of oceanographic research. Although no solution is offered for these possible relations between tidal currents—horizontal and vertical—and the distribution of temperature, density, salinity, and the chemical constituents of sea water, this concluding section furnishes an invaluable stimulus to the student of oceanography. It shows the student with scholarly modesty and frankness how very young the science of the sea still is, indicating a great number of puzzles as yet waiting solution.

H. A. Bauer

Postscript to "The Circumnavigation of Franz Josef Land"

In reference to his prediction of weather conditions in the Kara and Barents seas in 1933 Mr. Zubov sends a correction that arrives too late for incorporation in his paper (see p. 401). His previous conclusions were based on observed temperatures of the North Cape Current in May, 1932, and on temperatures reported for the Norwegian Sea in 1931. However the abnormally low figures for the latter appear to have been applicable to surface waters of the northern Norwegian fiords rather than to the oceanic waters. August and November temperatures of the North Cape Current proved not so low as had been anticipated: apparently the deep layers remained very warm. The temperature of the current began to rise and good ice conditions may be forecast for the Kara and Barents seas in 1933. The *Knipovich* reached the 80th parallel in January of this year, encountering only "slush" and the *Krasin* visited Cape Jelaniya in March.

Mr. Zubov sends sketch maps of Victoria Island (astronomical observations from the ship off the southeastern corner of the island gave a position of 80° 08′ N. and 37° 00′ W.) and Evaliv. Both are ice-cap islands though the borders of Evaliv are not steep walls and a black "comb" of rock appears on the eastern slope of the western dome. The existence of Freeden Island is doubtful: it could not be seen though visibility was excellent. The routes of the *Knipovich* also suggest that Cape Mary Harmsworth is placed 20 nautical miles too far west on existing charts.